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THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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COMING MEETINGS OF THE SOCIETY

March 13 (*Thursday*), *New York City*, Engineering Societies Building. Joint Meeting with the Society of Illuminating Engineers and the American Museum of Safety. Addresses: Industrial Lighting, by Ward Harrison, engineering department, National Electric Light Association; How to Prevent Fifty Per Cent of Industrial Accidents, by Dr. W. H. Tolman, director, American Museum of Safety; also an address by Dr. Alger of the Sage Foundation for the Prevention of Blindness. Discussion is invited, and all persons who intend to participate should communicate with F. A. Waldron, 37 Wall Street, New York. Informal dinner, 6.30 p.m., Keen's English Chop House, 70 W. 36th St. Kindly notify H. R. Cobleigh, 505 Pearl St., of intention to be present.

March 20, Cincinnati, Ohio, Address: Engineering and Common Sense, Wm. Kent.

March 25, Boston, Mass. Paper on Textiles, Frank W. Reynolds.

April 8, *New York City*, Engineering Societies Building. In charge of the Sub-Committee on Railroads. Subject: Steel Car Construction. To be discussed by W. F. Keisel, Jr., E. W. Summers, J. A. Pilcher, H. A. Currie, F. W. Butt, H. M. Estabrook, S. P. Bush, C. T. Westlake, and others. See further details on page 5.

April 16, *New Haven, Conn.*, Mason Laboratory, Yale University. Subject for afternoon session: Factory Heating; for evening session, Factory Lighting.

May 20–23, *Baltimore, Md.*, Spring Meeting. Headquarters, Hotel Belvedere. See Tentative Program on page 3.

June 21–*July* 8, Joint Meeting with Verein deutscher Ingenieure, Leipzig, and various industrial cities of Germany. See page 7 for Tentative Program.

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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THE SPRING MEETING

The program for the Spring Meeting at Baltimore, May 20–23, has been tentatively arranged by the Committee on Meetings and the Local Committee at Baltimore. The headquarters will be the Hotel Belvedere and the professional sessions and various social functions will also be held at the Belvedere. The meeting will open on Tuesday evening with an informal reception; on Wednesday and Thursday mornings there will be professional sessions, and Wednesday and Thursday afternoons will be devoted to excursions, with an entertaining lecture on Wednesday evening and a reception and dance on Thursday evening. The whole day on Friday will be occupied with a trip to Annapolis.

It is the purpose of the Committee on Meetings to reduce the number of professional meetings to a few strong sessions at which, because of their great interest, there will be a large attendance and thorough discussion. As at present arranged, these are to be confined to three sessions. The opening one on Wednesday morning will consist of a brief business meeting, followed by papers on certain phases of the patent situation and the performance of automobile trucks. Simultaneous with this will be the meeting of the Gas Power Section, for which two papers are promised, one on oil-engine practice abroad, and one on blast-furnace gas. On Thursday morning, the whole session will be devoted to the subject of fire protection,

two of the papers being published in this issue, upon the new high-pressure fire system at Baltimore, and the important question of standard couplings for fire apparatus. Supplementing this meeting there will be a demonstration of the high-pressure fire system in the afternoon, with trips also to inspect other public works, including the sewage disposal plant.

The Local Committee, Layton F. Smith, Chairman, have carefully prepared the program for entertainment, under the supervision of a special committee, and these events, which are outlined herewith, should not only be most enjoyable, as is always the case when members of the Society come together, but of real interest because of the opportunities which the city of Baltimore is able to offer.

In accordance with what is deemed to be a wise policy for the Society to adopt for its various meetings, the Committee on Meetings have urged that the Local Committee permit the visiting members to share in the expenses of the entertainment to the extent of paying for their fares, luncheons, and similar expenditures, rather than burden local members with the necessity of raising funds for these purposes.

As the meeting is to be held at a time of the year when there are many visitors in Baltimore, members are urged to make their hotel reservations early. These must be made personally in every instance. Besides the Belvedere, there is the Stafford, which is only three and one-half blocks away, and the Hotel Emerson which is an eight-minute ride on the trolley.

TENTATIVE PROGRAM

Tuesday, May 20

8.00 p. m. Informal Reception at headquarters

Wednesday, May 21

9.30 a. m. Business Meeting at Headquarters
Professional Session with miscellaneous papers
Gas Power Session

12.30 p. m. Excursion to McCall's Ferry, Dam and Power House. If a sufficient number desire to make this trip, a special train will be provided at $1.80 per passenger for the round trip; otherwise the fare of $2.68 will be charged
Other trips will be arranged for those who do not desire to visit the power plant
The ladies will participate in an automobile trip, with tea served at the Country Club

Evening Lecture at Headquarters; subject and speaker to be announced later

Thursday, May 22

9.30 a. m.	Session on Fire Protection at Headquarters
Afternoon	Trip over Jones' Falls conduits, inspection of sewerage pumping plant, and trip by trolley to sewage disposal plant at Back River Exhibition of high-pressure fire service
Evening	Reception and Dance at Headquarters. The members will be the guests of the Engineers Club of Baltimore on this occasion

Friday, May 23

The entire day will be devoted to a trip to Annapolis. The party will leave Baltimore at 9 a.m., by a commodious excursion steamer, going down the Patapsco River, past Fort McHenry and other forts, Sparrows Point, down the Chesapeake Bay, into the Severn River, and thence to Annapolis. This is a trip of unusual beauty. Upon arrival the Society will be welcomed at the Governor's mansion, after which there will be opportunity to visit points of interest. The Society will be accorded the privilege of the use of the House of Delegates and the Senate Chamber for such meetings as it may desire to hold. An address will be given at the Capitol at 2 p.m. by Admiral H. I. Cone, Mem.Am.Soc.M.E., Engineer-in-Chief of the Bureau of Steam Engineering, U.S.N., upon the United States Experimental Station at Annapolis.

Following this members interested may inspect the station. It is understood that there will be hydroaeroplane flights by officers and men of the aviation school, and possibly some evolutions of the submarine boats stationed at Annapolis at that time. The Naval Academy will be open for inspection during the afternoon.

The expenses of the trip will be $3, including luncheon and supper. Those desiring to return early may do so by electric trolley, the ride to Baltimore taking one and one-half hours.

MEETINGS IN CHICAGO

The recently organized Chicago section of the Society held its first regular professional meeting on February 6, a report of which is given at the back of this issue of The Journal. Previously two organization meetings had been held, as reported in the February number of The Journal. At the recent meeting the subject for discussion was Combustion Engines, with addresses by E. T. Adams, Prof. Chas. R. Richards, J. C. Miller, Nisbet Latta, and others. About 65 were in attendance and the discussion was of exceptional value, giving promise of marked success and a growing interest for future meetings. There is every reason to believe that one of the largest and strongest groups of the Society will be gradually developed in Chicago in the spirit of coöperation which has been manifest in other cities. In this way the local sections of the other national societies in Chicago, the Western Society of Engineers, the Engineers Club, and our own organization, can be of mutual service in the promotion of the various branches of engineering.

NEW YORK MEETING, APRIL 8

There is a large representation of railroad men in the membership of the Society, and on April 8 the regular New York meeting will be in the interests of this part of the membership and of railroad men generally in the vicinity of New York. The subject of Steel Car Construction has been assigned to the meeting, and the Sub-Committee on Railroads, which held such a successful session at the Annual Meeting, will have charge of the program. So far as known there has never been a meeting of engineers to discuss steel car construction, and it is the intention to bring before the Society the very latest developments of the art by specialists in each feature of steel passenger car design. It will be a meeting that should fill the auditorium.

The speakers who have accepted and the subjects assigned to them are given below, and other phases of the subject will be presented by other authorities, announcement of which cannot be made until later.

Problems of Steel Car Designs, W. F. KIESEL, JR., assistant mechanical engineer, Pa. RR. Co.

Suspension of Steel Cars, E. W. SUMMERS, Summers Steel Car Co.

Trucks for Steel Passenger Cars, J. A. PILCHER, mechanical engineer, Norfolk & Western Ry.

Provision for Electric Lighting in Steel Cars, H. A. CURRIE, assistant electrical engineer, N.Y.C. & H.R.R.R. Co.

Provision for Electrical Equipment on Steel Motor Cars, F. W. BUTT, assistant engineer, N.Y.C. & H.R.R.R. Co.

Special Ends for Steel Passenger Cars, H. M. ESTABROOK, president, Barney & Smith Car Co.

Draft Gears for Steel Passenger Cars, S. P. BUSH, Buckeye Steel Castings Co.

Cast Steel Double Body Bolts and End Frames for Steel Cars, C. T. WESTLAKE, chief mechanical engineer, Commonwealth Steel Co.

AMERICAN ACADEMY OF POLITICAL AND SOCIAL SCIENCE

The seventeenth annual meeting of the American Academy of Political and Social Science will be held in Philadelphia on April 4 and 5, 1913, and will partake of the nature of a National Conference. The entire six sessions will be devoted to the subject of the cost of living in the United States. The leading professional and commercial organizations of the country have been invited to participate, with the idea of securing enlightenment, through interchange of opinion, on the different phases of this important question.

MEETING IN GERMANY, 1913

The itinerary of the visit of the Society to Germany by invitation of the Verein deutscher Ingenieure and in connection with its annual meeting will be as follows:

TENTATIVE PROGRAM

NEW YORK

Tuesday, June 10

10.00 a. m. The party sails on the Hamburg-American S. S. Victoria Luise (remodeled "Deutschland") from Hoboken. It will be advisable for members of the party to reach New York not later than June 9.

Representatives of the Verein deutscher Ingenieure will come on board at Cherbourg to receive the visitors.

HAMBURG

Thursday, June 19

Arrival in Hamburg.

Friday, June 20

11.00 a. m. Address: The Hamburg Harbor
11.00 a. m. to 1.00 p. m. Trip around the harbor
5.30 p. m. Reception in the Municipal Hall by the Senate of the city and by the Hamburg Section of the Verein deutscher Ingenieure

Saturday, June 21

10.00 a. m. Excursions
Group 1: Inspection of the Elbe tunnel and visit to the shipyards of Blohm and Voss
Group 2: Visit to the Vulcan yards and inspection of the Elbe tunnel

Sunday, June 22

10.00 a. m. Departure for Leipzig

LEIPZIG

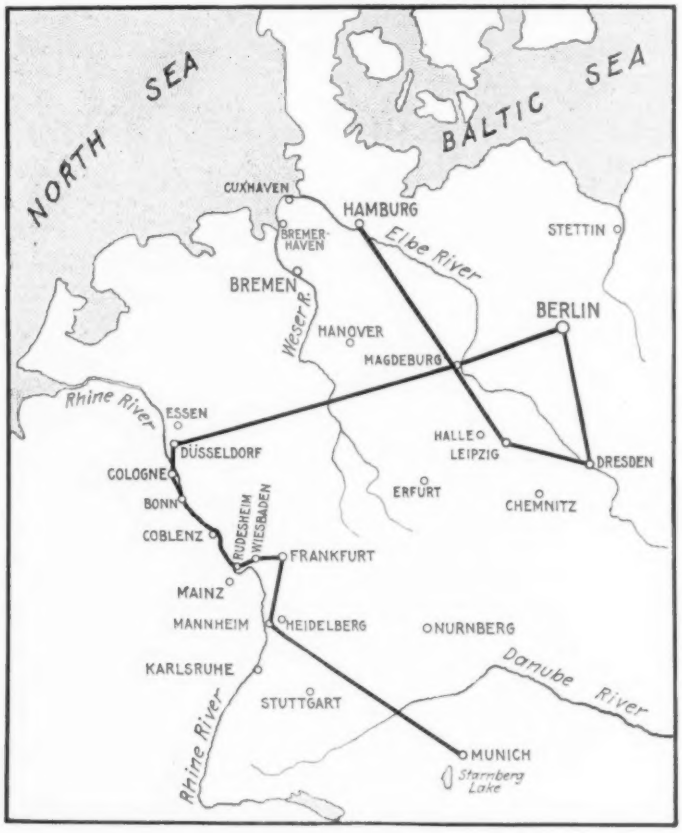
Sunday, June 22

4.30 p. m. Arrival in Leipzig
8.00 p. m. Reception in the Crystal Palace

LEIPZIG

Monday, June 23

10.00 a. m. Formal meeting in the Municipal Hall
5.00 p. m. Concert under the direction of Mr. Arthur Nikisch in the Gewandhaus
7.30 p. m. Formal dinner in Central Theater



ITINERARY OF OFFICIAL TOUR IN GERMANY

Tuesday, June 24

9.30 a. m. Scientific Lectures in the lecture room of the Architectural Exhibition
4.30 p. m. Inspection of the Monument of the Battle of Nations in commemoration of 100th anniversary of the battle of Leipzig, 1813
8.00 p. m. Festival in the Palm Garden

LEIPZIG

Wednesday, June 25

9.10 a. m. Departure for Dresden

DRESDEN

Wednesday, June 25

11.00 a. m. Arrival in Dresden
2.00 p. m. Gather at the Belvedere; automobile trip to the Saxon Switzerland (Bastei), walk to Rathen, by steamer to Pirna, by automobile to Dresden.
8.30 p. m. Reception in the Municipal Building, tendered by the city of Dresden.

Thursday, June 26

9.30 a. m. Excursion through Dresden
Group 3: Machine Laboratory of the Technical High School
Group 4: Seidel & Naumann Sewing Machine and Bicycle Factory
Group 5: Picture Gallery
12.30 p. m. Lunch in the Neustadt railway terminal
2.00 p. m. Departure for Berlin

BERLIN

Thursday, June 26

5.00 p. m. Arrival in Berlin
8.00 p. m. Reception in the Reichstag Building

Friday, June 27

9.30 a. m. Excursions
Group 6: Allgemeine-Elektricitäts Gesellschaft
Group 7: Siemens-Schuckert Works
Group 8: Bergmann Electrical Company
Group 9: Ludwig Loewe Company, Machine Tool Factory
Group 10: A. Borsig Locomotive Works in Berlin-Tegel
Group 11: Ladies' excursion and lunch
8.00 p. m. Formal dinner in the Zoological Garden

Saturday, June 28

2.30 p. m. Automobile trip to Potsdam and steamer trip on the Havel
7.00 p. m. Entertainment by the Berlin Local Section in Wannsee

Sunday, June 29

8.00 a. m. Departure for Düsseldorf, Rhine-Westphalia

DÜSSELDORF

Sunday, June 29

6.00 p. m. Arrival in Düsseldorf
8.00 p. m. Reception in the City Hall tendered by the city of Düsseldorf

DÜSSELDORF

Monday, June 30

9.00 a. m. Excursions

Group 12: Duisburg works of the German Machine Works Company (50 participants)

Group 13: Friedrich-Alfred steel plant of the Friedr. Krupp Co. in Rheinhausen (75 participants)

Group 14: Machine Works of Thyssen & Co. in Muhlheim (Ruhr) (20 participants)

Group 15: Gutehoffnung Steel Plant, Oberhausen Rheinland (40 participants)

Group 16: Rhein Steel Works, Duisburg-Meiderich (50 participants)

Group 17: In the morning the ladies inspect the city of Düsseldorf, and in the evening the welfare activities of Friedr. Krupp Co. in Essen

Group 18: Afternoon inspection of the Duisburg-Ruhrort harbor by the members of groups 12 to 16, as well as others who apply for it

The other visitors will be afforded an opportunity to see the city of Düsseldorf

8.00 p. m. Banquet in the city concert hall of Düsseldorf tendered by the Rhine-Westphalian Section of the Verein deutscher Ingenieure

Tuesday, July 1

9.00 a. m. Excursions

Group 19: Haniel & Lueg, Düsseldorf-Grafenberg (50 participants)

Group 20: Ernst Schiess Company, Düsseldorf (50 participants)

Group 21: German Machine Works Company, Benrath plant, Benrath (50 participants)

Group 22: Steel Works of Becker Company, Willich b./Krefeld (75 participants)

Group 23: Trip into the mountains; inspection of the Elberfeld Lift railway, Barmer mountain railway, steel plant of Rich. Lindeberg Company, Remscheid-Hasten and the Mungsten Bridge

Group 24: The ladies will inspect some installations in the city of Düsseldorf

4.30 p. m. Departure for Cologne. Members of Group 23 go from Remscheid direct to Cologne

COLOGNE

Tuesday, July 1

5.30 p. m. Arrival in Cologne

8.00 p. m. Informal gathering in the Zoological Garden of Cologne tendered by the Rhine-Westfalen Board. Trip on the Rhine with illumination of the city and cathedral

COLOGNE

Wednesday, July 2

9.00 a. m. Excursions
- Group 25: Dye Works, formerly Friedr. Bayer & Co. Leverkusen (up to 100 participants)
- Group 26: Gas Engine Works, Deutz, Cologne-Deutz (up to 100 participants)
- Group 27: Machine Works Humboldt, Cologne-Kalk (up to 100 participants)
- Group 28: The ladies inspect the cathedral and city

8.00 p. m. Reception in Gurzenich tendered by the city of Cologne

Thursday, July 3

8.00 a. m. Departure by rail for Coblenz; thence on the Rhine by steamer to Rüdesheim, where there will be a festival on the banks, and thence by rail to Frankfort-on-Main

FRANKFORT-ON-MAIN

Thursday, July 3

6.00 p. m. Arrival in Frankfort-on-Main

8.00 p. m. Reception in the Palm Garden by the Frankfort Section of the Verein deutscher Ingenieure

Friday, July 4

11.30 a. m. Welcome by the city in Roemer. Luncheon

2.30 p. m. Excursions
- Group 29: Eastern port and gas works
- Group 30: Stockyards and gasholders
- Group 31: Refuse destroyer plant and filters
- Group 32: Inspection of the old city, Goethe house, Historical Museum
- Group 33: Visit to Saalburg

7.30 p. m. Independence Day celebration with the American colony

Saturday, July 5

10.30 a. m. Departure for Mannheim

MANNHEIM

Saturday, July 5

12.00 m. Arrival; lunch in the Friedrichspark

Excursions
- Group 34: Machine Works, Heinrich Lanz
- Group 35: Machine Works, Sulzer Bros. in Ludwigshafen
- Group 36: Brown-Boveri & Co., electric machinery
- Group 37: Cement Works in Leinen and their welfare activities

Group 38: Benz & Co. Rhine Automobile and Motor Works Company
Group 39: Inspection of the port (steam flour mills in Ludwigshafen)
8.00 p. m. Reception of welcome

Sunday, July 6

11.00 a. m. Departure for Heidelberg

HEIDELBERG

Sunday, July 6

12.00 m. Arrival; lunch in the Stadtgarten, inspection of the Castle, concert in the Castle Restaurant
6.00 p. m. Dinner on the Molkenkur tendered by the Board of Reception
10.00 p. m. Trip to the Castle, illuminated by fireworks, given by the City of Heidelberg
11.00 p. m. Return to Mannheim

MANNHEIM

Monday, July 7

10.00 a. m. Departure for Munich

MUNICH

Monday, July 7

5.00 p. m. Arrival in Munich
8.00 p. m. Reception of welcome in the Hofbrauhaus

Tuesday, July 8

9.30 a. m. Inspection of the German Museum and its new building
3.00 p. m. Trip to the Sternberger See
8.00 p. m. Concluding exercises in the Rathhaus

The Verein deutscher Ingenieure has extended the trip one day beyond that previously announced, making the concluding date July 8.

The Hamburg-American Line, which have charge of the outgoing trip on the S. S. Victoria Luise have been commissioned by the Committee to take complete charge also of the land trip. The entire cost of the land trip from Hamburg to Munich inclusive will be $82.

The ticket for the land tour includes transportation in second-class carriages on the trains, first-class on the steamers, lodging and breakfast (i. e., rolls and coffee) in first-class hotels. For luncheon and dinner we are for the entire trip the guests of the Verein. If any one does not participate in the excursions or functions in which these meals are included and secures them elsewhere, they must be paid

for extra. If more is desired for breakfast, that will also be an extra charge.

An estimated minimum cost of the entire trip is as follows:

Outgoing voyage on S. S. Victoria Luise (minimum)	$97.50
Official trip through Germany to Munich	82.00
*Second class ticket from Munich to seaport (estimated)	11.00
Return voyage (estimated)	100.00
	$290.50

To this amount there should be added the usual fees to stewards, etc., on the ocean passage, tips in hotels, and such amounts for extra meals and service in hotels, etc., as the individual may require.

All reservations for the ocean and land trips should be made direct with the Hamburg-American Line at their New York office or at the branch offices in the following cities: San Francisco, Boston, Philadelphia, Chicago, St. Louis and Pittsburgh. No other than the above principal and branch offices may take reservations, as this is a special steamer at special rates for our party. Owing to the common desire of most American tourists to return at approximately the same time, it is almost essential that all secure their return voyage accommodations at the time of making bookings for the outgoing trip.

Formal afternoon dress, i. e., top hat, frock or cutaway coat, are expected on several occasions, and frequent evening functions will require full evening dress.

By special arrangement of the Hamburg-American Line, in addition to hand baggage, 110 pounds may be carried on the land tour free of charge; the usual amount, 165 pounds, may be carried free of charge on board ship. Any excess baggage will be charged for extra at the usual rates.

The Hamburg-American Line have cabled, in regard to the question of providing individual rooms in the hotels, that they will do their utmost to meet the request, but they cannot guarantee to do so in every case, as in some cities this will be practically impossible. Further, in most of the hotels there are available only a few rooms with bath. Any who wish such special accommodations are advised to take up the matter immediately with the New York office of the Hamburg-American Line. In this case, of course, the regular hotel charges will be made.

The Verein deutscher Ingenieure is preparing for the use of all

* Preferable for railway travel in Germany.

participants a detailed guide-book for the trip, containing a general description of the cities to be visited and of all the industrial establishments included in the tour.

Members and guests have been duly notified through circulars issued by the Committee and the Hamburg-American Line and through the announcements in the monthly issues of The Journal and at the Annual Meeting, of the necessity of a definite decision regarding participation in the trip, either securing accommodation on the Victoria Luise, or announcing their intention to join the party in Hamburg; and the Committee feel absolved from any responsibility as to disappointments later.

Separate tickets must be secured for the land tour and it must be clearly understood that every one who goes on the steamship may not go in the official party on land.

A considerable number over the limit of 300 set by our hosts have indicated their intention of going and have requested that they be included in the official party. Members were given preference up to February 1, as had been announced, and since that date, they have been permitted to file applications for guests.

The Committee have decided that inasmuch as the option on the steamship expires March 1, and about that time our hosts must be notified of the number in our party, that from now on only those are to be regarded as members of the official party, who take reservations on the steamship or who advise the Committee definitely that they will join the party on June 19 in Hamburg, or on June 22 in Leipzig, and who will purchase their tickets in Germany.

The following is a list of those who comprise the official party to date, having either made reservations on the S. S. Victoria Luise, or intending to join the party abroad:

OFFICIAL PARTY

ADAMSON, DANIEL
ADAMSON, MRS. DANIEL
ALDRICH, JOHN G.
ALDRICH, MRS. JOHN G.
ALEXANDER, M. W.
ARMSTRONG, MISS HELEN E.
BATES, FRANCIS E.
BELL, JAMES R.
BELL, MRS. JAMES R.
BINLEY, WM., JR.
BINLEY, MRS. WM., JR.
BOENIG, ROBERT W.
BOND, GEO. M.
BRAUN, H. H.
BRAUN, MRS. H. H.
BRECKENRIDGE, L. P.
BRECKENRIDGE, MRS. L. P.
BRIGGS, LEROY E.
BRINTON, W. C.
BROWN, R. S.
BROWN, MRS. R. S.
BUNNELL, S. H.
BUNNELL, MRS. S. H.
BURLEIGH, P. GRAY
BURSLEY, J. A.
BUTTOLPH, BENJ. G.
BUTTOLPH, MRS. BENJ. G.
CHRISTIE, A. G.
COLE, F. J.
COLE, MRS. F. J.

Conroy, R. A.
Dart, W. C.
DeBaufre, Wm. L.
DeBaufre, Mrs. Wm. L.
Dickerman, A. C.
Doble, Wm. A.
Doble, Mrs. Wm. A.
Dodge, James M.
Estabrook, M.
Easton, Miss M. E.
Eyermann, Peter
Eyermann, Mrs. Peter
Felker, Geo. F.
Fellows, E. R.
Fellows, Mrs. E. R.
Foucar, E. L.
Foucar, Mrs. E. L.
Freeman, John R.
Freeman, Mrs. John R.
French, L. G.
French, Mrs. L. G.
Fuller, Arthur A.
Fuller, Mrs. Arthur A.
Garratt, E. A.
Garratt, Mrs. E. A.
Gleason, Miss Kate
Greene, Arthur M., Jr.
Greene, Mrs. Arthur M., Jr.
Guilbert, H. M.
Guilbert, Mrs. H. M.
Hall, Carl A.
Hall, Mrs. Carl A.
Hall, James A.
Hartness, James
Hartness, Mrs. James
Heap, Douglas T.
Heap, Mrs. Douglas T.
Hersey, M. D.
Hess, H. D.
Hess, Mrs. H. D.
Jackson, A. C.
Jennings, A. L.
Jennings, Mrs. A. L.
Jessen, N. B.
Keely, R. R.
Keller, E. E.
Kent, Wm.
Klein, Arthur W.
Kothny, G. L.
LeBlond, R. K.
LeBlond, Mrs. R. K.
Leland, H. M.
Leland, Mrs. H. M.
Low, Fred R.
Low, Mrs. Fred R.
Lummis, C. W.
Macon, W. W.
Marburg, L. C.
Merriman, Mansfield
Merriman, Mrs. Mansfield
Miller, T. H.
Miller, Mrs. T. H.
Moore, Samuel L.
Moore, Mrs. Samuel L.
Moore, Miss Selma J
Morgan, L. H.
Morgan, Mrs. L. H.
Morgan, W. F.
Morgan, Mrs. W. F.
Morse, A. H.
Morse, Mrs. A. H.
Nickel, F. F.
Nickel, Mrs. F. F.
O'Reilly, Mrs. E. R.
O'Reilly, Miss
Pennock, G. A.
Phillips, Francis C.
Plimpton, Chester H.
Reist, H. G.
Reist, Mrs. H. G.
Rice, Calvin W.
Rice, Mrs. Calvin W.
Richards, C. R.
Robeson, A. M.
Robeson, Mrs. A. M.
Roe, J. W.
Roesler, Rudolf
Saegmuller, G. N.
Sahlin, Axel
Sahlin, Mrs. Axel
Schlachter, C.
Schlachter, Mrs. C.
Schmidt, C. R.
Schmidt, Mrs. C. R.
Schmidt, E. L.
Schmidt, Mrs. F. L.
deSchweinitz, P. B.
Seligman, Walter
Seward, Miss Dora
Seward, Miss Madeline
Shaw, J. C.
Shearer, C. A.
Simon, Arthur
Simon, Mrs. Arthur
Skinner, A. C.
Smith, A. Parker
Smith, Harold B.
Smith, Mrs. Harold B.
Smith, Jesse M.
Smith, Mrs. Jesse M
Snow, Walter B.
Snow, Miss
Soverhill, H. A.
Soverhill, Mrs. H. A.
Stebbins, Theodore
Stebbins, Mrs. Theodore
Sunstrom, K. J.
Sunstrom, Mrs. K. J.
Taylor, Frank H.
Taylor, Mrs. Frank H.
Taylor, J. W.
Taylor, Mrs. J. W.
Taylor, Miss
Thorkelson, H. J.

THORKELSON, MRS. H. J.
THURSTON, E. D., JR.
THURSTON, MRS. E. D., JR.
DETRAMPE, A.
DETRAMPE, COUNTESS
TROTZ, J. O. E.
TROTZ, MRS. J. O. E.
WALLICHS, A. O.
WALLICHS, MRS. A. O.
WALKER, CHARLES A.
WARNER, WORCESTER R.
WARNER, MRS. WORCESTER R.
WHITEFORD, JAMES F.
WHITEFORD, MRS. JAMES F.
WHITLOCK, E. H.
WHITLOCK, MRS. E. H.

UNITED ENGINEERING SOCIETY

REPORT OF TREASURER

To the Board of Trustees
United Engineering Society

I beg to submit herewith the report of your Treasurer as of December 31, 1912.

FINANCES

The Balance Sheet, submitted herewith, shows the physical property of the United Engineering Society, over and above the value of building and the equity in the land, to consist of building equipment of a value of $26,624.72, furniture and fixtures $6005, and library books $329.07.

There was added to the furniture and fixtures account during the year 1912 an amount representing an expenditure of $1383.77 including oak desk, table and chairs in library, also four large oak tables and twenty-four chairs to be used in the assembly rooms, safe for Superintendent's office, and two Edison business phonographs. In accordance with a resolution of the Board of Trustees, 10 per cent depreciation was charged off this account for the year 1912.

The principal of the mortgage on the land held by Andrew Carnegie, Esq., amounting originally to $540,000 has been reduced by payments from the Land and Building Funds of the Founder Societies to $128,000. There have been no further payments made during the year by the Founder Societies and the balances due from the societies remain the same as last year, namely, American Institute of Electrical Engineers $54,000, and American Institute of Mining Engineers $74,000. The American Society of Mechanical Engineers has paid the full amount of its indebtedness.

The gross operating expenses for the year 1912 were $47,602.71, an increase over the year 1911 of $9323.56, which is accounted for by the following unusual expenditure authorized in the minutes of the Board of Trustees: The expenditure for improving ventilating system in auditorium; storm windows fifth floor; interior painting, driveway repairs, iron fence, storm door western entrance, and re-

equipping 101 thermostats (including an augmented pay roll of $548.66) amounted to $7910.96, the main item being $4562.50 expended on ventilating system. An additional sum of $2034.75 was expended in alterations, which was reimbursed by the different societies for whom the charges were made.

In accordance with a resolution of the Board at a meeting held on January 25, 1912, an appropriation of $5000 was made out of the surplus for the year 1911, and of this amount $4755 was invested in $6000 Southern Railway Development and General Mortgage 4 per cent Bonds due 1956 at 79¼, as an addition to the contingency and renewal fund as provided for in the Founders Agreement, bringing the invested amount of the reserve fund up to $25,020. It is recommended that a similar appropriation be made out of the available balance from this year's operations which will then show a balance to be added to surplus account of $952.19.

The assessments paid for the year by the Founder Societies, each occupying an entire floor, were $3375 (against $4500 each for the year 1911), representing a total expenditure by each Founder Society, including interest on its full principal of mortgage on land, of $10,575, reduced in each case to the extent the society may have paid off part or all of its mortgage share. The Associates are assessed approximately $10,000 for equivalent facilities, which shows that the Founder Societies still meet a little more than their proportion of the carrying charges for equivalent office space occupancy in the building.

BUILDING

Equipment. The real estate equipment account during the year 1912 has been increased to an extent of $1587, expended mainly in needed electrical work in the library.

Office Occupancy. There was on January 1, 1913, no unoccupied floor space devoted to office use in the building. There are, however, two rooms on the twelfth floor formerly used for storage purposes and now temporarily used by the library, from which no income has been received during the year.

Meetings or Lectures. The record of the number of times the rooms were used during 1912 for meetings or lectures (not for office occupancy) is:

Meeting Room		Number of Times Occupied 1911	1912	Change
Auditorium	3d and 4th floors	44	46	2 more
No. 1 Assembly Room	5th floor	40	39	1 less
2 Assembly Room	5th floor	54	70	16 more
3 Assembly Room	5th floor	10	33	23 more

Lecture Room No. 5	6th floor	34	35	1 more
Lecture Room No. 6	6th floor	7	0*	7 less
Lecture Room No. 8	6th floor	86	84	2 less
Small Committee Room	7th floor	26	12*	14 less
Total		301	319	18 more

* No. 6 Lecture Room is now occupied by the American Museum of Safety, and the small committee room as an office by the Aeronautical Society.

During the year 1912 the facilities of the building were enjoyed by 60 societies holding a total of 253 meetings, with an attendance of 42,324, as contrasted with 251 meetings during 1911, with an attendance of 42,400.

LIBRARY

During the year 1912 there was added to the library of the three Founder Societies and United Engineering Society, 3183 volumes and pamphlets, of which 1103 volumes and pamphlets were purchased at a cost of $3819.16. The total number of books and pamphlets in the library at the end of the year is 50,683.

The attendance during the year was 10,522 as compared with 11,014 during 1911, a slight decrease.

The department of research work has been developed as far as the present force will permit. One hundred and sixty searches have been made on a great variety of subjects in answer to requests received from correspondents in Japan, South Africa, Mexico, Canada and England, as well as from different parts of the United States, including several hundred photographic reproductions.

The library receives more than 700 technical periodicals which are available through indexes for research purposes.

Respectfully submitted,

(*Signed*) Jos. Struthers,

Treasurer

UNITED ENGINEERING SOCIETY

Balance Sheet, January 1, 1913

ASSETS

Real estate, land	$ 540,000.00
Real estate, building	1,050,000.00
Real estate, equipment	26,624.72
Furniture and fixtures	6,005.00
New York City bonds (cost) reserve	5,231.25
New York City bonds (cost) reserve	5,062.50
Baltimore & Ohio bonds (cost) reserve	5,037.50
The Delaware & Hudson Company bonds (cost) reserve	4,933.75
Southern Railway Company	4,755.00
Library Books, United Engineering Society	329.07
Library, adjustment accounts	161.58

Accounts receivable		5,035.60
Unexpired insurance		1,362.69
Cash		
Working balance	$7376.68	
For reserve fund	5000.00	
Ways and Means Committee	1165.08	
		13,541.76
Petty cash		500.00
		$1,668,580.42

LIABILITIES

Balance of land mortgage, A.I.E.E.	$54,000.00	
Balance of land mortgage, A.I.M.E.	74,000.00	
		$128,000.00
A.I.E.E. equity in building		350,000.00
A.S.M.E. equity in building		350,000.00
A.I.M.E. equity in building		350,000.00
A.I.E.E. equity in real estate equipment		3,346.61
A.S.M.E. equity in real estate equipment		3,346.62
A.I.M.E. equity in real estate equipment		3,346.62
A.I.E.E. payments to date in liquidation of mortgage on land		126,000.00
A.S.M.E. payments to date in liquidation of mortgage on land		180,000.00
A.I.M.E. payments to date in liquidation of mortgage on land		106,000.00
Depreciation and reserve fund		30,000.00
Ways and Means Committee		1,165.08
Library adjustment accounts		118.08
Accounts payable		2,024.56
Surplus account		35,232.85
		$1,668,580.42

STATEMENT OF RECEIPTS AND DISBURSEMENTS, YEAR ENDING DECEMBER 31, 1912

CASH RECEIPTS

Balance on hand, January 1, 1912	$11,308.45
Account of interest on mortgage	5,120.00
Assessment of Founder Societies	11,250.00
Assessment of Associate Societies, offices, meetings, etc.	45,213.94
Notes receivable	551.00
Library account	8,114.80
Interest on bonds and deposits	1,436.33
	$82,994.52

DISBURSEMENTS

Account of interest on mortgage	$5,120.00
Account of real estate equipment	1,587.00
Operating expense, cash expenditures	45,926.39

Furniture and fixtures	1,054.33
Library account	8,114.80
Bonds purchased (reserve)	4,755.00
Accrued interest on bonds purchased	116.00
Accounts payable (from 1911)	1,113.71
A.I.M.E. office space released	858.00
Insurance	235.95
Library adjustment	432.25
Library books, U.E.S.	139.33
Balance onhand, January 1, 1913	13,541.76
	$82,994.52

Operating Income and Expenses, Year Ending December 31, 1912

INCOME

Assessment Founder Societies	$10,125.00	
Less refund for office space released	1,111.00	
		$9,014.00
Assessment Associate Societies		26,647.76
Assessment miscellaneous (offices and meetings)		8,810.75
Telephone returns		4,181.23
Miscellaneous charges to Societies		4,900.15
U.E.S. library book returns		48.45
U.E.S. library returns		63.50
Interest		1,320.33
		$54,986.17

EXPENSES

Operating expenses, gross	$47,042.10
Reserve fund	5,000.00
Insurance	917.30
Depreciation on furniture and fixtures	233.45
Balance carried to surplus account	1,793.32
	$54,986.17

JOHN FRITZ

John Fritz died at his home, Bethlehem, Pa., on February 13, 1913, in the 91st year of his age. For over sixty years he was actively engaged in the upbuilding of the iron and steel industry, that period when practically every advance in the art took place which contributed to the great engineering achievements of the present day.

There is in the possession of The American Society of Mechanical Engineers a hand-turning tool used by John Fritz when learning his trade, in place of the usual slide rest and fixed tool. In 1896, when President of the Society, Mr. Fritz in his presidential address reviewed the progress in the manufacture of iron and steel, and showed a full size drawing of the most modern type of heavy lathe of that day, weighing over 190,000 pounds. The drawing was much too long to be hung on one wall of what was then the auditorium of the Society, and in contrast with it the hand tool was shown, illustrating in a most striking manner the remarkable development in machine shop practice during the professional life of one man, and typical also of changes correspondingly great in every other department of the iron industry.

In his Autobiography, published last year, John Fritz begins the first chapter by saying, "I was born August 21, 1822, in Londonderry Township, Chester County, Pa., and was the oldest child of a family of seven children, three brothers and four sisters. I was born of parents of exemplary character, my father being a man of high moral standards; he fully impressed upon my mind the importance of absolute integrity, energy and economy. My mother was a true Christian woman . . . to my mind, the moral and religious training received from my parents was the most important training I could have possibly received; and I have ever thought the highest honor I could pay to their memory was to endeavor to follow their noble example."

His father was a millwright by trade and lived on a small farm, and John worked on the farm until sixteen years of age. This was before the days of public schools in that section

and his education was obtained at district schools which kept three months in the winter and three months in the summer. The work on the farm, however, and the difficulties encountered in securing an education were but as endowments to his character which, combined with the sturdy stock of his ancestry, caused him resolutely to master the great problems of his later years. Along with these qualities which contributed to his success, were those other finer ones which made for him the many warm friendships both among his business associates and the workmen who were under him.

In 1838 he started to learn his trade as blacksmith and machinist. His most important early work was done at Norristown, Pa., where he went in 1844 to assist in building the Norristown Iron Works, and where he was soon placed in charge of all the machinery of the plant. This was a responsible position and an onerous one. There were three sets of rolls in the mill, all driven by one engine, and so much trouble was experienced with the gearing that he became hostile to all geared mills and determined that if opportunity ever offered, he would build a mill direct-driven without the use of gears. In spite of the long hours and many difficulties encountered at Norristown, young Fritz determined to become proficient in all branches of the iron industry, and regularly spent his evenings until a late hour at work at the puddling furnace and in other departments of the mill.

In 1854 Mr. Fritz went to Johnstown, Pa., as general superintendent of the Cambria Iron Works. He was employed to remodel and rebuild the plant. The mill was of such a design and was so incomplete in many ways, that he found it impossible to make the rolling of rails in the ordinary way of commercial success. He therefore asked the proprietors to build a mill according to his long-cherished plan, one with three-high rolls, direct-driven, without gearing. This proposition met with the most strenuous opposition, resulting in Mr. Fritz giving an ultimatum to the effect that this step must be taken and that he would not consent to build a geared mill. Permission was at last granted and with the introduction of the three-high system of rolling and other improvements, the Cambria Iron Works became the greatest plant of the time.

The final period of Mr. Fritz' career began in 1860 with his removal to Bethlehem, Pa., to become the general superintendent and chief engineer of the Bethlehem Iron Company, and to

design and erect the company's plant. Three years later the rolling of rails was commenced and the plant was universally recognized to be remarkable in its conception and design. Here there were successive developments, which Mr. Fritz directed until his retirement. Among them were the Bessemer plant, the open-hearth process, the 125-ton steam hammer, the largest in the world, intended to produce more perfect forgings than possible with smaller hammers, the Whitworth fluid compression process with its 14,000-ton hydraulic forging press, operated by 15,000-horsepower engine and pumps, and the massive tools required for machining the forgings, and the armor plate plant for making steel plates by the Creusot process. The importance of this and similar forging plants in this country in making possible the heavy types of machinery which were constructed in the latter part of the century, such as the power units at Niagara Falls, and the large steam engines which immediately preceded the development of the steam turbine, cannot be overestimated.

Besides his active work with the various companies with which he was connected, Mr. Fritz designed for the Government a rail rolling mill erected at Chattanooga, Tenn., during the Civil War, and made plans and specifications for an armor plant for the Government, which, however, was not constructed.

Mr. Fritz received many high honors from various engineering societies and educational institutions. He was president of the American Institute of Mining Engineers in 1894, president of The American Society of Mechanical Engineers in 1896 and Honorary Member of this Society and of the American Society of Civil Engineers. He received the Bessemer gold medal of the Iron and Steel Institute of Great Britain and was elected Honorary Member of that Society. Honorary degrees were conferred on him by Columbia University, the University of Pennsylvania, Stevens Institute of Technology and Temple University.

Perhaps no greater mark of esteem has ever been bestowed on an engineer than that tendered Mr. Fritz in commemoration of his seventieth birthday. A banquet was proposed by members of the Engineers Club of New York, at first with the idea of a small affair. As the plans developed, however, 300 friends and associates sought the privilege of attendance, among whom were distinguished representatives of the Government and of many institutions and firms, necessitating the use of the Grand Opera

House at Bethlehem for the dinner. It was one of the most notable meetings in the annals of American engineering.

Ten years later, at the time of his eightieth birthday, a banquet was held in Mr. Fritz's honor at the Waldorf-Astoria in New York which also signalized the founding of the John Fritz medal by members of the four national engineering societies, a permanent fund being contributed for the annual purchase of the medal. In this way his friends have assured the perpetuation of the memory of his achievements in industrial progress.

When Lehigh University was founded in 1866, Mr. Fritz was selected as one of the original trustees and he was deeply interested in the success of the institution, as evidenced by the establishment through his generosity of the John Fritz engineering laboratory; and in his will there is provision for the further endowment of this institution.

He further made a fitting memorial to his parents in the erection at South Bethlehem of the Fritz Memorial Methodist Episcopal church and parsonage.

Of Mr. Fritz's family there survive only two sisters, a niece and three nephews. His wife died in 1908, and their only child in 1860.

The life of Mr. Fritz constitutes one of the most notable examples of an American born of poor parents and with limited education who achieved by his own personal qualities the highest success, not only in material things but in reputation and a wide circle of friends. A most interesting portrayal of his life and characteristics is afforded by the accompanying letter which we are privileged to publish through the courtesy of the Engineering News. This was written by Mr. Fritz several years ago in response to a request from Dr. W. F. M. Goss, Dean of the College of Engineering, University of Illinois, President of this Society. The letter was asked for as an inspiration to engineering students, and with the permission of Dr. Goss it has been made public.

My dear sir—Yours of Feb. 16, making inquiry in regard to my application to business, is before me. This is rather a delicate question for me to answer, as I have at all times tried to avoid notoriety as much as possible, and I request you to give what I write as little publicity as possible, consistent with the purpose you want it for, which I suppose is for an example for students who will not give their studies proper attention. I will therefore give you a very brief outline of my rule of application to business, to which I attribute my success—whatever it may have been.

I was apprenticed in the old-fashioned way, being bound out for a

given number of years to learn blacksmithing and the country machine trade. In 1845 I left my home to try my fortune in the world, and went to Phoenixville in order to get work in the rolling mill, but was told that business was very dull, and that they had more men than they knew what to do with.

I there learned that a new mill was building at Norristown, and at once concluded to go there and see if I could get something to do. I went direct to the office and told the proprietors what I wanted, and was told that they had more men than they wanted; their mill was not completed, and if it were finished, times were so dull they would not start it.

I left the office, and in going back to the street, I walked through the mill and was looking at some of the machinery when one of the owners came into the mill and came up to me. I thought that he might order me out, but these thoughts were soon dispelled.

After a pleasant talk, he asked me if I was used to hard work, to which I frankly answered, "Yes." Then he wanted to know where I was raised. I told him on a farm and what I had been doing. To all of his questions I gave him a prompt answer. He then said: "Young man, I like thy looks. Will thee remain until Monday?" I replied by saying that if there was any probability of my getting employment, I would be pleased to remain over Sunday. He then said that the manager was absent, but was expected to be at the works on Monday morning, and I should call about eight or nine o'clock.

I remained over, but it was both a long and an anxious period from Saturday evening until Monday morning in a strange place. At length the appointed time came around, and I was on hand promptly. In a short time Mr. Moore, accompanied by a large, fine-looking man, came near where I was standing and halted, and had a short conversation in an undertone. To me this was a most trying ordeal, as I supposed it was to determine my fate.

After the brief conversation, they walked up to where I was standing. Mr. Moore introduced the gentleman as John Griffin, the Manager. * * * After some hesitation, I told him what I wanted. He asked what I had been doing and if I was afraid of hard work. I answered both questions in a manner that seemed satisfactory to him. He told me to come to work the next morning.

When I entered the mill the next day to go to work, I fully realized the fact that I was among entire strangers without friends or prestige, or compass to direct my course, with mind untrained for systematic work or study, and with but scant education. My thoughts naturally went back to the scenes of my boyhood days—to the old home where my kind parents and loving sisters and brothers remained. I now fully realized that I was enlisted in the army for the great battle of life, and made up my mind that I would faithfully do my duty in whatever position chance might place me, always keeping my eyes and ears open and my mouth shut. This is important. A man who is an habitual talker is an abominable nuisance about a plant, and no manager wants him.

In 1845 or 1846, then, I succeeded in getting a job—now called a situation—in the Norristown Iron Works as a country machinist, who at that

day was not considered worth much. I started in at $1.25 per day, but my pay was soon raised to $1.50, that being the regular machinist rate of wages.

I was at the works with tools in hand when the bell rang. I idled no time away, and was ready and willing to do anything I was called on to do, and did it willingly, pleasantly, and with energy. The result was that when the mill was completed and put in operation, I was placed in charge of all the machinery in the plant, which to me was a great surprise.

Having previously made up my mind that the iron business would become a leading one, I was now placed in a position to get a very general knowledge of rolling-mill practice—a very important branch of it. But I soon made up my mind that to be a success, it was essential to learn all branches of it practically.

At that time puddling was the most important, the most difficult, and the most laborious of all branches of the business. But in face of all its difficulties, it was clear to my mind that I should learn it. As my time was occupied during the day, it had to be learned in off hours, which meant at night. After having my supper, I used to return to the mill and work at the puddling furnace until ten o'clock—at times later—every night, Saturday and Sunday nights excepted. This was no child's play, but I was on hand every night that the mill ran until I was well posted in the art.

About this time, there was another great surprise for me. I was called to the office without knowing what it was for, and I confess even at this late day, I well remember that as I had never been sent for before, I went to the office with some fear that they were in some way dissatisfied with me. When I entered, I found both partners in their private room and both of them seemed in a pleasant mood.

Now this is especially for your boys, and they should commit it to memory and ever have it in mind.

Mr. Moore, the senior partner, said that the man (calling him by name) who had charge of the mill in the night time, was not giving satisfaction, and they had dismissed him and wanted me to take his place. I was amazed for a moment. After gathering myself together again I said to them: "I do not want the position, and if I did, there are four other men (naming them) that are older than I and have been with you longer than I have." Two of them were nephews of Mr. Moore, and the other two were friends of both Mr. Moore and Mr. Hoover, the proprietors of the works.

Mr. Moore, who was the spokesman and a friend, said: "John, if I were going to look for thee any time after thee got thy supper till ten or eleven o'clock, I should come to the mill; if for either of the others, I should look over the town, and we insist upon thee accepting the position. To us, it is very important to have a person there at night that we have full confidence in."

Consequently I accepted, though reluctantly, as I was fearful that it might in a measure interfere with my opportunity of gaining practical knowledge of the manufacture of iron. Fortunately, I had gained a good knowledge of the art of puddling, which to learn properly made it neces-

sary to be at the furnace from the time the heat was charged until the metal was finished, taken out and rolled, which required some two hours.

In learning to puddle, I acquired the skill necessary to work a furnace properly, which assisted me very much in becoming a heater. Learning to roll was not at all difficult, for being a blacksmith, handling the tongs came naturally, besides I was not confined to any given length of time. I could take the tongs and roll for five minutes, more or less, as the opportunity occurred. But getting up the templates for the rolls at that time was quite another matter. Having but little experience and no books on the subjects, at least none that we knew of, we had to think them over thoroughly and experiment with them until they would work all right.

Having now graduated in all the branches in the mill, in the manufacture of bar iron, pipe iron, boiler plate, tank iron, band iron, nails, car axles, shafting, heavy rounds and squares, and about all kinds and sizes of iron that were there being manufactured, I concluded that the rail business, although in a most deplorable condition at that time, would eventually become a leading branch of the iron business, and made up my mind that it would be important to know something about that.

At this time there was a rail mill going to be built at Safe Harbor, near Lancaster, Pennsylvania, and the owners wanted me to go there to erect the machinery in the mill. This was just what I wanted to do. At once I had a talk on the subject with Mr. Moore and Mr. Hoover, * * * and they finally consented to let me go.

When I left Norristown, I went directly to Safe Harbor and put the machinery in place, and remained there some two years, being finally driven away by fever and ague. I then returned to Norristown to my old place.

When Mr. Reeves learned that I had left Safe Harbor, he sent for me to come and see him, and he wanted me to go to Phoenixville and take charge of the machinery and shops there * * * .

I then had a private talk with Mr. Moore, saying to him that I had now had practical experience in all branches of the manufacture of iron except the work of the blast furnace, which is the first of all, and that I could not be a thorough, practical ironmaster without having a practical knowledge of the blast furnace. He said that the view which I took was quite correct, and consented to let me go after some work that I had on hand was completed; after that was finished he said he would be satisfied to let me go, and to this arrangement Mr. Hoover subsequently agreed.

I now took hold of the project of remodeling and rebuilding the furnace and getting it in blast. This was accomplished with complete success, and I remained with Mr. Reeves about two years. I then returned to Messrs. Moore and Hoover to make some improvements in their mill.

Having obtained a very general knowledge of the iron business, both in the mechanical and practical working of the same, and also in the conversion of pig iron to wrought, and putting it in shape for the market, I, in company with others, put up a foundry and machine shop, with the view of remodeling and building blast-furnace and rolling-mill machinery.

Before the shops were completed, Mr. David Reeves, in company with a few others, leased the Cambria Works at Johnstown, Pennsylvania, and insisted on my taking the position of general superintendent; and he having strong claims on me, I accepted the position—whether wisely or unwisely I have never been able to determine.

The plant was new, yet it was not possible to make a commercial success with it without many changes and betterments, which involved the remodeling and rebuilding of the whole plant. This I did, and at the expiration of six years of the most strenuous labor, I left the works with their acknowledged supremacy as the best rolling-mill plant in the world.

On the morning of July 5, 1860, I bade Cambria Iron Works people goodbye and arrived in Bethlehem the same evening; and on the morning of the sixth, I entered the employ of the Bethlehem Iron Co. and built the iron and steel plant, and later on erected the hydraulic forging plant, the machine shop, and the armor-plate plant and finishing shop.

Now a word about application to business. It has been my rule through life to be at the works every morning, Sundays excepted, winter and summer, at half past six, breakfast being over before I leave the house. This gives me time, if anything has gone wrong in the night, to make arrangements for the repair men to go directly to whatever place they are needed, and to see that all the men are in their places. It is always better to say "Come boys" than "Go boys," and an hour in the morning is worth more than two in the afternoon.

At half past eleven, some of the principal foremen go to their dinner, and about half past twelve they return. Then I go to my dinner and return about two o'clock. I get my supper about half past six and return to the works at half past seven and remain until half past nine; then I go home and go to bed at ten o'clock sharp, unless something is going wrong at the works, and then I know no hours until it is righted.

One Monday morning about one o'clock, we had not finished what were called "Sunday repairs," and * * * I was waiting for the job to come back. * * * I noticed an Irishman standing leaning on his shovel, looking at me. After a little while he walked over to where I was standing and said to me: "Mr. Fritz, I was standing looking and thinking and wondering how long you have been in an iron works." I said to him: "Some thirty-odd years." He said, "I have been with you nineteen years, and you have been making time and half time ever since I have been with you."

I write this to show that men do not often hurt themselves by hard work and long hours if they take proper care of themselves.

Outside of fever and ague, typhoid fever, pneumonia, and an attack of erysipelas, the time I was away from the works on account of sickness would not average over one day in a year. This seems remarkable, as I was exposed to all kinds of temperatures—going from the hot furnaces out in to the cold in winter, when the thermometer was down to ten. No matter how badly it stormed, I was at the works attending to my duties, and rarely took a cold.

My first work in the iron line was in 1838 at a charcoal furnace which made about 16 tons per week; the total production that year in the United States was 263,000 tons. This year (1905), at the rate it is now going, it is supposed that the production will exceed 20,000,000 tons.

I have not only been contemporary with the marvelous improvements that have taken place in the iron and steel industry, but have had much to do with their introduction and perfection.

In regard to the fifteen years you refer to, when I was building the Bethlehem gun-forging and armor-plate plant, one thing I did was to go abroad to see what they were doing on the other side of the water. I saw most of the large iron and steel and forging plants in England, Germany, Belgium and France, and was absent from home only about six weeks; and I think it was about the hardest work I ever did, except the building, organizing and getting the works started and the steel to stand the high physical test required by the government for the gun forgings and armor-plate.

It was my rule to make my own foremen, selecting them out of the men employed in the works, but when we came to select men to do work they had never seen, it was something of a task; but it was done and not one of the men selected to take charge had ever seen a plant for doing the kind of work he was called on to do.

The best and hardest and most difficult work of my life was done when I was between 65 and 73 years of age, yet many well-minded people are under the impression that men over 45 are quite useless. They seem to forget the fact that experience counts for much. An experienced man does his work better, faster and easier for himself and those around him than a novice, although a much younger man. A man with experience has confidence in himself, knows what he is doing, and does not hesitate. He goes ahead with the assurance that he is right.

My life has been an active one in the most laborious, exacting and important branch of manufacture in the domain of human activities, requiring courage, endurance, and a most varied talent. In August next (1906), I shall be 83 years old, and I am now hearty and active, both mentally and physically, and do not think that I am yet a proper subject for chloroform.

As representatives of the Society the Council appointed the following Honorary Vice-Presidents to attend the funeral of John Fritz at Bethlehem on February 19: Frederick R. Hutton, Jesse M. Smith, H. G. Stott, Alfred Noble, Calvin W. Rice, John R. Freeman, John A. Brashear, Henry R. Towne. These, with about twenty friends from the Engineers Club, the American Institute of Mining Engineers and the John Fritz Board of Award, went on a special train from New York. There was a large attendance of the immediate family and friends, and hundreds of people of the city in which Mr. Fritz had lived for so many years were grouped about the house and on the street at the time of the service. The entire company followed the body to the cemetery where the simple service of the Moravian Church was conducted.

COST OF UPKEEP OF HORSE-DRAWN VEHICLES AGAINST ELECTRIC VEHICLES

By W. R. Metz

ABSTRACT OF PAPER

A great deal has been written on the subject of motor trucks versus horse-drawn vehicles, but it appears to be extremely difficult to obtain exact figures, as most firms regard the item of hauling as an overhead expense not worthy of the minute examination given to the other departments.

The motor-driven vehicle is unquestionably cheaper to operate than is the horse drawn vehicle where a number of vehicles are used, and, in the opinion of the writer, the only question to be determined is the advisability of using electric or gasolene-driven machines. From figures on hand, it appears that the cost of upkeep of the gasolene-driven machines is about double per mile that of the electric-driven machines (not including driver's or helper's wages), but, on the other hand, the gasolene-driven machines have a much larger radius of operation and, in certain cases, this would more than offset the cheaper upkeep expense of the electric-driven machine.

As a general proposition, it appears that the electric-driven machine is better for city service where the streets are in fairly good condition, and that the gasolene-driven machine is better for long hauls over rough roads and in the open country, mainly on account of the ability to obtain gasolene and water, and the chances of making greater speed.

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By W. R. Metz, Washington, D. C.

Member of the Society

During the fall of 1910 the writer and the accountant of our office were instructed to submit a report as to the desirability of purchasing motor trucks to replace horse-drawn wagons, and an investigation was made covering certain government departments and private firms. This report was submitted in November 1910, and it was estimated that the office would save approximately $11,000 per annum if electric vehicles were purchased and all of the horse-drawn equipment sold.

2 This report was approved and equipment purchased as outlined herein, and the results were most gratifying as the saving during the first year was nearly $12,000, in spite of the fact that, during this year, only a part of the electric truck equipment was purchased and six horses were kept. Five of these horses have since been sold, and the saving during the next year will undoubtedly be increased.

PRELIMINARY INVESTIGATION

3 The naval gun factory at Washington operated five electric trucks, two of which had been in operation for four years; one of these had a capacity of 2500 lb., and the other a capacity of 5 tons. The first was furnished by the McCrea Motor Company of Ohio, and the other by the Studebaker Company. The cost of operation and the saving accomplished were as given in Table 1.

5-TON ELECTRIC TRUCK

4 The cost of operating this truck was about the same as the

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

TABLE 1 2500-LB. ELECTRIC TRUCK

Cost of Truck	$2230.00	
Labor for charging batteries		$46.44
Charging		16.50
Acid		18.00
Rubber jars		15.00
Batteries (partly renewed)		64.98
Carbon brushes		1.80
Repairs		99.96
1 Operator at $2.48 per day		776.24
2 Laborers at $1.92 per day each		1201.92
Totals	$2230.00	$2240.84
Depreciation 10 per cent		223.00
Interest on investment at 2 per cent		44.60
Total cost		$2508.44
Total Mileage per Year	3366	
Cost per mile	$0.745	
This truck displaced 5 horses and carts, costing as follows:		
5 Carts by contract at $1.92 per day		$3004.80
5 Laborers at $1.92 per day each		3004.80
Total		$6009.60
Net Saving of Truck over Horses per Year =	$3501.16	

2500-lb. wagon, excepting that the 2500-lb. wagon cost 75 cents for charging per 40 mile radius while the 5-ton truck cost $1.10 for the same radius. The total cost of operation is given as $2396.84, and if depreciation and interest on the investment of $3725 are included the total cost will be $2843.84.

5 This truck displaced two 2-horse wagons costing as follows:

3 Laborers, each wagon, at $1.92 per day	$3605.76
Stabling, shoeing, etc., 4 horses at $4 per day	1252.00
Total	$4857.76
Net Saving of Truck over Horses	$2460.92

In this case depreciation and interest are not included as the original cost of the horses was not known.

6 One large company operates a number of horse-drawn wagons, also a number of motor trucks, both electric and gasolene driven. Their experience is given in Table 2.

TABLE 2 HORSE-DRAWN VEHICLES

Investment		
1 Horse	$250.00	
1 Vehicle	125.00	
Harness	30.00	
Total	$405.00	
Maintenance and Upkeep		
Depreciation		
Horse at 20 per cent	$50.00	
Vehicle at 15 per cent	18.75	
Harness at 15 per cent	4.50	
Interest on $405 at 6 per cent	24.30	
Total		$97.55
Horse Upkeep		
Feed at 47.4 cents × 365 days	$173.01	
Shoeing at 7.5 cents × 365 days	27.38	
Veterinary at 1.1 cents × 365 days	4.02	
Total		204.41
Vehicle Expense at 43.4 cents per day	$158.35	
Harness Expense	4.50	
Total		162.85
Total Expense exclusive of Labor and Stable		$464.81

7 From Table 2 can be estimated the yearly expense of vehicles requiring more than one horse, by adding the items for horses and harness to the one-horse vehicle costs as follows:

1-Horse vehicle expense	$464.81
Vehicle and 2 horses expense $464.81 plus $275.71	740.52
Vehicle and 3 horses expense $740.52 plus $275.71	1016.23
Vehicle and 4 horses expense $1016.23 plus $275.71	1291.94

These costs do not include labor and stable expense.

8 In Table 3 are given the costs of operation for the electric trucks used by this same company. Table 4 compares the operation costs of the first two trucks recorded in Table 3 on the basis of 300 days' service per year. Table 5 makes a similar comparison of the commercial and individual gasolene machines assuming 300 days' service per year for the former and 365 days for the latter. The following makes of gasolene cars were in use: Cadillac, Brush, Buick, Ford, Franklin and Maxwell, ranging from 10 h.p. to 30 h.p.

9 In addition to the records obtained from this company, the

TABLE 3 EXPENSE OF OPERATING ELECTRIC COMMERCIAL VEHICLES

Capacity, Lb.	850–1000	1500–2000	2500–3000	4000	7000
Interest and Depreciation (Machine less Batteries and Tires)	$244.50	$306.30	$391.40	$422.94	$470.84
Mechanical and Electrical Upkeep	67.54	84.15	101.70	110.96	121.42
Tire Repairs and Renewals	79.28	97.30	155.05	267.60	535.25
Battery Repairs, Cleaning and Renewals	130.50	175.36	219.34	271.54	312.84
Current at 1 cent per kw-hr.	20.00	30.20	40.00	60.00	51.50
Totals	$541.82	$693.31	$907.49	$1133.04	$1491.85

TABLE 4 TOTAL MILEAGE OF THE FIRST TWO CARS, AND THE COST PER MILE OF EACH, EXCLUSIVE OF INTEREST AND DEPRECIATION

Capacity, Lb.	Miles per Day	Miles per Year	Cost per Year	Cost per Mile
850 to 1000	25	7500	$297.32	$0.04
1500 to 2000	25	9125	$277.01	$0.03

TABLE 5 COST AND MILEAGE OF COMMERCIAL AND INDIVIDUAL MACHINES

Service	Miles per Day	Miles per Year	Total Cost per Year	Cost per Mile
Commercial	22.2	6660	$896.69	$0.135
Individual	19.7	7190	809.53	0.1125

TABLE 6 COMPARATIVE EXPENSE OF OPERATING MOTOR VEHICLES IN PLACE OF HORSE-DRAWN VEHICLES

Vehicles for Emergency Work		
Two 2-horse vehicles at $740.52	$1481.04	
One 3-horse vehicle at $1016.23	1016.23	
		$2497.27
One 4000-lb. automobile	$1133.54	
One 2500-lb. automobile	907.49	
		$2040.53
Annual Saving by Use of Automobiles, not including Labor		$456.74
Supply Wagon		
One 4-mule wagon	$1291.94	
One 4000-lb. automobile	1133.04	
Annual Saving		$158.90
Paymaster's Money Wagon		
One 2-horse vehicle	$740.52	
One 850 to 1000-lb. vehicle	541.82	
Annual Saving		$198.70

attempt was made to secure data from a number of private firms, but unfortunately none of them had any exact figures and could only approximate the savings due to the use of both electric and gasolene-driven trucks over horse-drawn vehicles.

VEHICLES IN USE BY OUR OFFICE

10 During the fiscal year 1910 and 1911, which were the last two years that horse-drawn vehicles were used exclusively, the total expenses for the stable were $31,113.58 for 1910, and $31,231.93 for 1911; and for the same years the cost of the delivery section was $17,093.93 for 1910, and $17,256.19 for 1911, making a total cost for the delivery and stable sections of $48,207.51 for 1910, and $48,488.12 for 1911. It should be stated here that the stable and delivery sections were entirely separate at this time, each being in charge of a foreman, whereas after the automobiles were used these sections were combined, although the costs were separated.

11 The equipment, number of men employed, and the expenses of the stable and delivery sections during the fiscal year 1910 are given in Table 7.

12 Omitting the wages paid the drivers and messengers, the stable section alone cost $18,447.37, making the cost per horse per year $802.06, or $2.20 per day, of which $37\frac{3}{4}$ cents was for feed.

TABLE 7 EQUIPMENT, NUMBER AND CLASS OF MEN EMPLOYED, AND COST OF OPERATION, MAINTENANCE AND REPAIR FOR HORSE-DRAWN VEHICLES FOR YEAR ENDING JUNE 30, 1910

Equipment	Cost
23 Horses (average per year)	$6,900.00
Harness, blankets, etc.	1,350.00
1 Five-ton truck (2 horse)	425.00
7 Large delivery wagons (2 horse at $475.00 average)	3,325.00
6 Single delivery wagons (1 horse at $275.00 average)	1,650.00
3 Light mail wagons at $200	600.00
4 Depot wagons (carriages) at $300	1,200.00
2 Coupes, with pole and shafts, at $540	1,080.00
Total	$16,530.00

Number and Class of Men Employed

STABLE SECTION	DELIVERY SECTION
1 Foreman at $2000 per year	1 Foreman at $2000 per year
1 Mail carrier at $3.20 per day	4 Helpers at $3.04, 2.80, 2.72 and 2.40 per day
1 Messenger at $2.40 per day	12 Messengers at $2.40 per day
11 Drivers at $2.40 per day	2 Unskilled laborers at $2.00 per day
1 Stableman in charge at $2.88 per day	
8 Stablemen at $2.40 per day	

Total employees[1] in both sections = 42.

Cost of Operation of Stable Section	
Wages of foreman and stablemen	$10,113.59
Wages of drivers	12,666.21
Rent	2,400.00
Feed	3,172.20
Supplies	959.62
Repairs to harness, wagons, etc.	626.86
Shoeing	906.60
Gas and electricity	268.50
Total Cost of Operation, Maintenance and Repair	$31,113.58
Depreciation, Horses 20%, Harness 15%, Wagons 10%	2,410.50
Interest on Investment at 2%	330.60
Total Cost including Depreciation and Interest on Investment	$33,854.68
Cost of Operation of Delivery Section	
Salaries and wages	$17,085.93
Material and supplies	8.00
Total Cost	$17,093.93

[1] 20 per cent additional is allowed for night service.

13 From Table 7 can readily be obtained the operating cost of one 2-horse, 5000-lb. capacity wagon, and these are given in Table 8.

14 During the month of November 1911, there were purchased and put into service two 1000-lb. trucks, two 2000-lb. trucks, and

TABLE 8 COST PER YEAR OF ONE 2-HORSE, 5000-LB. CAPACITY WAGON

Wagon Expense			
Cost of truck	$425.00		
Cost of maintenance and repair		$31.75	
Cleaning and washing		66.76	
Lubricants		1.00	
Depreciation, estimated at 10%		42.50	
Total			$142.01
Horse Expense			
Cost of two horses	$615.00		
Cost of feed		$264.33	
Cost of care (hostler)		702.60	
Cost of veterinary and office labor		250.10	
Cost of medicine		2.17	
Cost of shoeing		78.84	
Cost of blankets, nets, etc	12.22		
Rental value of space (2 horses) (based on $2400 for 22 horses)		218.00	
Depreciation, estimated at 20%		125.44	
Total			$1641.48
Harness Expense			
Cost of harness	$123.00		
Cost of maintenance		$7.68	
Depreciation, estimated at 15%		18.45	
Total			$26.13
Miscellaneous Supplies		$10.00	
Drivers' Wages		751.20	
Helpers' Wages		751.20	
Gas and Electricity		23.34	
Interest on Investment at 2%		23.50	
Total			$1559.24
Total Original Cost	$1175.22		
Total Expense for One Year			$3368.86

two 5000-lb. trucks, all of the electric type, and at the same time 17 horses and their equipment were sold, leaving six horses, one 5-ton capacity, two-horse truck, one single-horse truck, one carriage driven by two horses, and one carriage driven by one horse.

15 In November 1912, one additional 5000-lb. truck and an electric-driven carriage were installed, and two carriage horses and one truck horse and their equipment were sold.

16 In January 1913, one 8000-lb. capacity truck was installed, and two more truck horses and their equipment were sold.

17 The truck equipment, and the number and class of men employed for caring for the electric vehicles and the remaining horses during the year 1912 is given in Table 9.

18 During the coming year, and after the remaining six horses are sold, the four stablemen will be dispensed with and in their place

TABLE 9 EQUIPMENT AND NUMBER AND CLASS OF MEN NOW EMPLOYED

Equipment		
Two 1000-lb. trucks	$4,639.00	
Two 2000-lb. trucks	5,498.78	
Three 5000-lb. trucks (two in use during full year)	10,625.22	
One 8000-lb. truck (installed in January 1913)	5,509.00	
One electric-driven carriage (installed in November)	3,671.00	
Total Cost		$29,943.00
Number and Class of Men Employed		
1 Foreman at $2000 per year	$2000.00	
12 Chauffeurs at $2.40 per day each	9024.40	
3 Helpers at $3.20, $2.80 and $2.72 per day	2729.36	
10 Messengers at $2.80 (two) and $2.40 (eight) per day	7762.40	
1 Mail carrier at $3.20 per day	1001.60	
2 Messenger boys at $1.20 each per day	751.20	
1 Stableman in charge at $4.00 per day	1252.00	
3 Stablemen at $2.40 each per day	2253.60	
2 Drivers at $2.40 each per day	1502.40	
35		$28,276.96

Note—Labor charge is based on day service.

there will be employed probably two helpers and one laborer at a total cost of $6.80 per day, or $2128.40, thus indicating a further reduction of $1377.20.

19 All of the electric trucks were purchased from the Baker Motor Vehicle Company, of Cleveland, Ohio, and the iron-clad exide storage batteries from the Electric Storage Battery Company, of Philadelphia, Pa.

20 It will be noted that there have been no tire costs during the year. This, of course, was due to the fact that none of the tires have worn out, but it should be stated that the tires on the 5000-lb. trucks

are practically worn out and, in fact, were being replaced during the month of January 1913, so that the tires on these trucks wore out after running since December 1911, or a period of 13 months. The tires on the 1000 and 2000-lb. trucks are still in fairly good condition. The tires on the 5000-lb. trucks would undoubtedly have lasted longer than they did were it not for the fact that these trucks were often loaded up to 7000 lb., making a considerably harder service than could have been anticipated by the makers.

21 The total cost of operating the combined delivery, stable, and garage during the year 1912 was as given in Table 10.

TABLE 10 SALARIES, WAGES, LEAVE OF ABSENCE, HOLIDAY AND LIABILITY PAYMENTS, MATERIAL AND SUPPLIES, REPAIRS, ETC., FOR DELIVERY, STABLE AND GARAGE, JANUARY 1, 1912 TO DECEMBER 31, 1912

Month	Salaries, Wages, Leave of Absence, Holiday and Liability Payments			Material and Supplies, Repairs, Etc.		
	Delivery	Stables	Garage	Delivery	Stables	Garage
January	$1,429.23	$523.71	$818.23	$14.75	$149.85	$223.87
February	1,330.59	465.88	822.56	2.74	127.06	224.89
March	1,345.76	487.61	828.97	2.28	189.36	240.67
April	1,245.10	484.17	891.61	13.51	76.21	197.08
May	1,378.52	543.23	1,019.64	25.55	114.27	183.87
June	1,141.73	453.61	821.78	66.96	213.18	495.99
July	1,454.96	512.77	887.06	9.40	124.35	173.57
August	1,372.38	447.99	889.27	6.00	127.84	251.64
September	1,487.09	429.50	678.68	4.34	122.55	198.60
October	1,391.65	443.33	710.59	9.94	129.54	307.26
November	1,565.02	337.95	809.68	1.35	57.76	222.40
December	1,460.70	252.00	910.13	13.95	48.81	203.41
Total	$16,602.73	$5381.75	$10,088.20	$170.77	$1480.78	$2923.25
Equipment issued January 1 to December 31, 1912			$70.00			$24,446.00

22 In Table 10 it is interesting to note that the six electric trucks, doing practically all of the work, cost only about twice as much as the six horses. As a matter of fact the six electric trucks alone did as much work as the total stable force did during the year previous, and the horse-drawn equipment simply took care of the increased work.

23 Table 11 shows in detail the cost of taking care of the electric trucks, and as the cost of the trucks of any given size is about the same, only one of each size is given.

TABLE 11 ELECTRIC VEHICLE RECORD

	1000-Lb.			2000-Lb.			5000-Lb.		
	Jan.–June	July–Dec.	Total	Jan.–June	July–Dec.	Total	Jan.–June	July–Dec.	Total
Total Miles	3013.00	3511.00	6524.00	2978.00	2864.00	5842.00	3586.00	2918.00	6504.00
Ampere Hours	8598.00	8459.00	17057.00	11019.00	9710.00	20929.00	18302.00	14096.00	32398.00
Ampere Hours per Mile	2.85	2.40	2.61	3.69	3.39	3.58	5.10	4.83	4.98
Kw-Hr. Supplied	1249.8	1303.80	2553.6	1573.6	1389.4	2963.00	2678.4	2047.8	4726.2
Cost of Current	$14.67	$16.64	$31.31	$18.58	$17.79	$36.37	$31.56	$26.28	$57.84
Battery Upkeep	.....	.....	.....	.....	.....	.....	.....	.....	.....
Tire Upkeep	.....	.....	.....	.....	.....	.....	.....	.....	.....
Electrical Upkeep	1.20	2.93	4.13	0.75	14.38	15.13	5.06	8.67	13.73
Mechanical Upkeep	26.80	27.68	54.48	41.34	28.41	69.75	129.62	80.10	209.72
Inspection	161.58	138.67	300.25	161.58	138.67	300.25	161.58	138.66	300.24
Totals	$204.25	$185.92	$390.17	$222.25	$199.25	$421.50	$327.82	$253.71	$581.53

24 From the given figures we can readily ascertain the cost of operating one 5000-lb. capacity electric truck as compared with one 5000-lb. capacity 2-horse wagon.

TABLE 12 COST OF OPERATING ONE 5000-LB. ELECTRIC TRUCK[1]

Cost of Truck and Equipment (including spare battery and parts)	$3745.00	
Maintenance and repair (as per statement above)		$581.53
Depreciation at 10%		374.50
Interest on investment at 2%		74.90
Chauffeur's wages at $2.40 per day		751.20
Messenger's wages at $2.40 per day		751.20
Total original cost	$3745.00	
Total expense for one year		$2533.33

The cost of two 2-horse wagons being $6737.72 (Table 7), the saving due to the use of the electric truck is $4204.39.

25 Unfortunately no mileage record of the horse-drawn vehicles was kept during the previous years, but the records show that the two-horse wagon made an average of four trips per day, and the present records show that the 5000-lb. electric trucks make an average of eight trips per day. The mileage of the electric trucks being about 24 per day, it may be assumed that the mileage of the horse-drawn trucks was about 12 per day.

26 For the sake of comparison the costs of the three sizes of electric trucks and of the two-horse wagon are given in Table 13. The average load on the 5000-lb. electric truck is 5500 lb., that on the 2000-lb. truck is 2500 lb., that on the 1000-lb. truck is 900 lb., and that on the 2-horse wagon was 4000 lb.

TABLE 13 COSTS OF ELECTRIC TRUCKS AND 2-HORSE WAGON

	2-Horse Wagon 5000 Lb. Capacity	5000-Lb. Electric Truck	2000-Lb. Electric Truck	1000-Lb. Electric Truck
Average Trips per Day	4	8	8	9
Mileage per Day, Average	12	24	20	20
Mileage per Month (Loaded Halfway)	312	624	520	520
Average Load per Trip, Lb.	4000	5500	2500	900
Total Load per Day, Lb.	16,000	44,000	20,000	8100
Tons	8	22	10	4.05
Total Load per Month, Tons of 2000 Lb.	208	572	260	105.3
Total Cost per Month	$280.74	$211.11	$187.81	$180.98
Cost per Mile	0.899	0.338	0.361	0.347
Cost per Mile (Omitting Driver's and Helper's Wages)	0.499	0.138	0.121	0.107

[1]One of these electric trucks easily replaces two 2-horse trucks.

27 The methods of keeping the records are given as a matter of interest. The Daily Meter Record and the Daily Charging Record are made out, one for each truck, by the employees in the garage. These are turned in to the office each morning and transferred to the Electrical Vehicle Record each month. This card is printed on both sides, thus providing space for a whole year.

28 The electrical and mechanical upkeep are obtained from the

GOVERNMENT PRINTING OFFICE
ELECTRICAL SECTION

DAILY METER RECORD—ELECTRICAL VEHICLE

Machine No..... *Battery No.....* *Date*....., 191

	READING OF ODOMETER	READING OF AMP. HR. METER	TIME	REMARKS
IN				
OUT				
DIFFERENCE ..				

FORM S—450

(*Signed*).....

GOVERNMENT PRINTING OFFICE
ELECTRICAL SECTION

DAILY CHARGING RECORD—ELECTRIC VEHICLES

Battery No..... *Date*..... 191

TIME	VOLTS	AMP.	SP.GR.	TEMP.

FORM S—447

(*Signed*).....

regular mechanics' work slips. Every machine in the office is given a number, and all repairs made and materials used are entered on the work slip and charged against the machine number and tabulated

in the office. In this way an accurate record is kept as to the cost of each machine.

29 Under inspection is charged the time for charging batteries,

FORM S-406

GOVERNMENT PRINTING OFFICE

OFFICE SUPT. OF BUILDINGS

ELECTRICAL VEHICLE RECORD MACHINE NO.....

MONTH	JAN.	FEB.	MAR.	APR.	MAY	JUNE
TOTAL MILES						
AMP. HRS. USED						
AMP. HRS. PER MILE						
K. W. HRS. SUPPLIED						
COST OF CURRENT						
BATTERY UPKEEP						
TIRE UPKEEP						
ELECTRICAL UPKEEP						
MECHANICAL UPKEEP						
INSPECTION						
TOTALS						

REMARKS .....

.....

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washing the trucks and similar miscellaneous work in the garage, and all of this cost is evenly distributed among all of the trucks in service.

SHADING IN MECHANICAL DRAWING

By Theodore W. Johnson

ABSTRACT OF PAPER

The object of this paper is to present a new rule for shading mechanical drawings, which comprehends the most important of the rules now used without their complexities and uncertainties and the controversies which arise from their use. The new rule is proposed with a view to reducing the art of shading to a precise and exact system in the interests of rapidity in the execution and reading of drawings and of their appearance.

SHADING IN MECHANICAL DRAWING

By Theodore W. Johnson, Annapolis, Md.

Associate Member of the Society

The rules so far advanced for shading, when carried to their logical conclusion result in too may shade lines, which cause delay both in executing the drawing and in reading it and are unsatisfactory to the eye. New rules and exceptions are required to bring theory into accord with simplified practice and to avoid the bewilderment which seems to result from the present complex rules.

2 One of the most recent and best compendiums of drawing[1] thus describes the common experience.

> It is possible by using two weights of lines, to add something to clearness and legibility of a drawing, and at the same time to give to its appearance a relief and finish very effective and desirable in some classes of work. . . . Shade lines are required on patent office drawings. . . . It is correct to use them whenever a gain in legibility and appearance is of sufficient importance to warrant the expenditure of the added time necessary. . . . The strict application of this theory (referring to a direction of light upon the object) would involve some trouble, and it is never done in practise, but the simple rule is followed of shading the lower and right hand lines of all figures.

3 So unsatisfactory is the situation that many engineers discard shading altogether as a waste of time. Properly used, shading is in many cases a great time saver. In spite of the breakdown of rules and divergence of practice, shading has a very real value. No better proof can be given than two figures taken from a standard work on mechanism. Fig. 1 is an illustration of an internal friction catch. Four catches *B* are forced by springs against an annular ring *A*. Without descriptive text one can sufficiently comprehend the geometrical shapes from the

[1] Engineering Drawing, by Thomas E. French. 1911.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

one view. Clearly one depends on the shading for proof that the action is internal and for the shape of the springs. Had a section been drawn, time would be needed for consulting it and for carrying the information (now given by the shading) back to the principal view.

4 Fig. 2 also shows an internal ratchet mechanism. By a draftsman's error the internal ratchet wheel has been shaded as if it were an external one. Here faulty shading clearly makes the drawing harder to understand than if it had not been shaded at all. It is a simpler mechanism than Fig. 1, yet students find it more difficult to understand on account of the faulty shading.

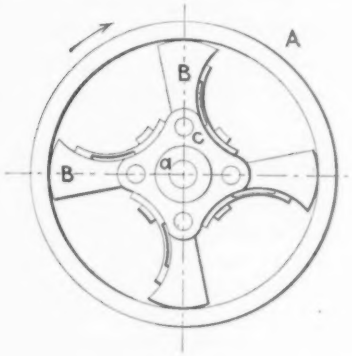

FIG. 1 SHOWING HOW SHADING AIDS IN READING A DRAWING

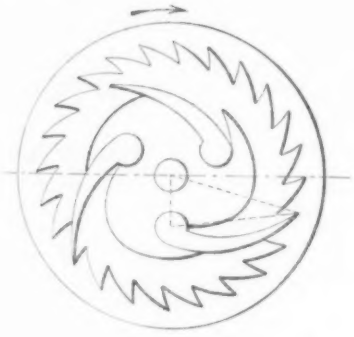

FIG. 2 EXAMPLE OF FAULTY SHADING

5 Two basic ideas have influenced shading:

I A shade line represents a shadow and as such should lie in any deep indentation of an object, or on any side far removed from the source of light.

II A shade line marks an edge which casts a shadow. It is placed therefore on any edge which separates an illuminated surface from a dark surface.

6 The first idea is the older. The second is an endeavor to be more precise. To apply it the direction of light must be specified. With curious unanimity authorities settled upon the body diagonal of a cube placed on the drawing-board square with the paper, as shown in Fig. 3. This makes the projected direction of light a 45-deg. line on the paper, and the true direction a line raised above it at an angle of 35 deg. 16 min.

7 In applying the second rule more precise results are ob-

tained than without it, but it becomes necessary to explain and modify it by new rules.

III A projecting part does not shade a lower part. The shadows cast have no finite length. Thus in Fig. 4 the projection *a* does not, in the front elevation, prevent light from reaching the surfaces *b*, *c* and *d*.

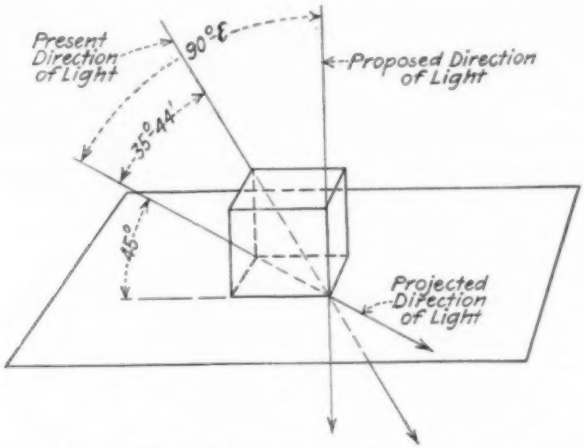

FIG 3 DIRECTION OF LIGHT AS NOW USED AND AS PROPOSED

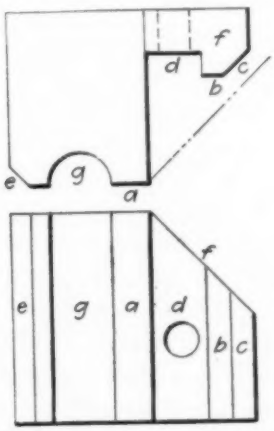

FIG. 4 DIAGRAM TO ILLUSTRATE SHADING OF INTERSECTING SURFACES

The edge of the bore hole and the right edge of the object are therefore shaded.

IV Forty-five-degree surfaces, such as *e* on the plan, Fig. 4, or *f* or *c* on the front elevation, have a tangent or skimming light and are considered as fully lighted.

8 Rules II, III and IV make a definite system which satisfies requirements, when no curved surfaces are encountered, except that they give too many shade lines. A general simplification better satisfying the eye and saving time results from a rule as follows:

V Never make the line of intersection of two planes, of which both can be seen, a shade line.[1]

9 The results of rules I, II and V are well shown contrasted by Figs. 5, 6 and 7, representing three ways of shading a screw thread. Fig. 5 is commonest in practice; Fig. 6 is advocated by text books, but has few followers; Fig. 7 is coming into general use because it is quicker and to my mind makes a better appearance. If the threads are shaded too great prominence is given to them.

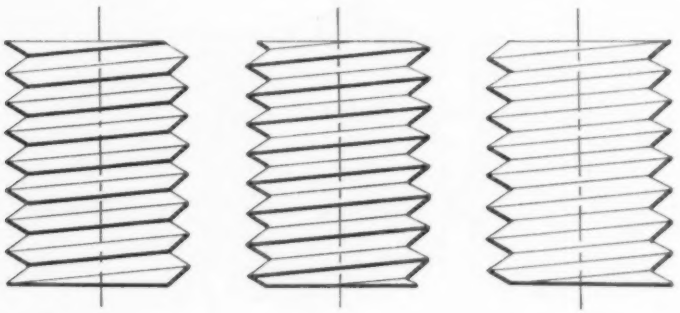

FIG. 5 FIG. 6 FIG. 7

FIGS. 5, 6 AND 7 SHADING OF SCREW THREADS ACCORDING TO RULES *a*, *b* AND *c*

10 Curved surfaces intersecting each other, or intersecting plane surfaces, should be treated by substituting for them the planes which are tangent to them at the line of intersection. In Fig. 4 the edge of the hollow half cylinder *g* is shaded on the front elevation for this reason. Difficulties still arise, however, even in so simple a case as a cylinder, which should be shaded as in Fig. 8, yet no one terminates the shade line on the end of the cylinder, side view, at *a*. Also the need of a shade line on the bottom edge, *b*, is so insistent that most draftsmen shade as in Fig. 9.

11 Rule V has simplified shading and is a long step in the right direction. Ten or 15 years ago, drawings from the Bureau of

[1] Wm. H. Thorne, Junior Course in Mechanical Drawing, 1888.

Steam Engineering of the Navy Department showed the crank arm shaded as in Fig. 10. Now they shade as in Fig. 11. Even with this rule, however, many controversial points are still unsettled.

12 So hard is it to keep five rules in mind that many authors give up the case and speak of shading by the "conventional method." "The right-hand and lower edges are made shade lines in all views." All this confusion can be swept away at one stroke. A single rule, covering or merging the five rules above, and also

FIG. 8 FIG. 9

FIGS. 8 AND 9 CYLINDER SHADING

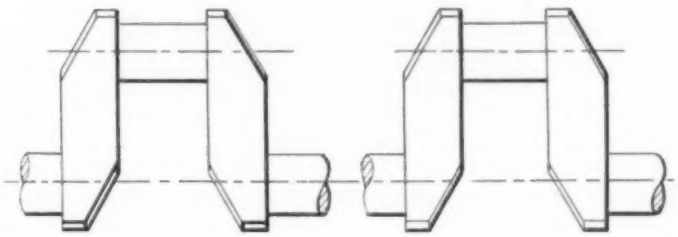

FIG. 10 FIG. 11

FIGS. 10 AND 11 TWO METHODS FOR SHADING CRANKSHAFTS

settling points about curved surfaces in line with the best practice, can be formulated as follows: *Shade lines mark edges which separate fully illuminated surfaces from surfaces which are quite dark, but the light upon the object comes from a point almost perpendicular to the paper, but inclined an infinitely small amount so that the projected direction of light is a 45-deg. line as at present.*

13 Referring to Fig. 3, the result is to raise the direction of light above the projected direction, from an angle 35 deg. 16 min., at which it now stands, to nearly 90 deg. Rules I and II are now merged and become the same thing. The shadow and the edge which casts the shadow remain together. Rule III is un-

necessary. The projected length of a shadow on the drawing is necessarily infinitely short. Rule IV is covered by the new rule. Rule V is automatically observed, because no surface which is seen as a surface (not "on edge") can be a dark surface. The "right and lower edges" of the "conventional method" can now be scientifically explained, instead of referring to examples, which at best is a case of shirking responsibility.

14 The practice of shading under this new rule will be that to which we are tending in all particulars: Fig. 4 for planes and hollow cylinders; Fig. 9 for a solid cylinder; Fig. 7 for

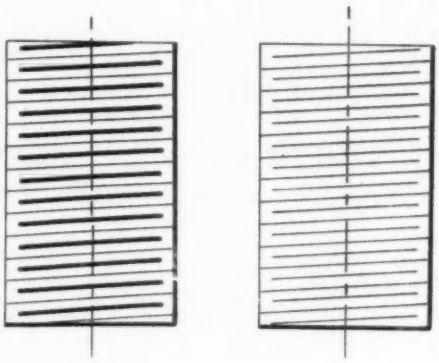

FIG. 12 FIG. 13

FIGS. 12 AND 13 CONVENTIONAL REPRESENTATION OF SCREW THREADS

screw threads; Fig. 11 for cylinders, cones, etc. Fig. 1 is correctly shaded and Fig. 2, with the exception of the internal ratchet wheel.

15 It may be well to mention that the conventional abbreviation of the screw thread will now be as in Fig. 13 instead of Fig. 12. Fig 12 is often used by draftsmen who otherwise do not shade at all, producing a result which is offensive to the eye. Fig. 13 is much more pleasing and there is a distinct saving in time, as it is not necessary to wait for one set of lines to dry before putting in the other, and the double handling of instruments is avoided.

16 If this rule is adopted, there will be no need for authors to write of shading. "The scientific method is universally taught and never practiced after the first blush of apprenticeship." Theory and practice will be in accord, and both will be simple.

THE PRESENT CONDITION OF THE PATENT LAW

INCLUDING RECENT AND PENDING DECISIONS OF THE SUPREME COURT OF THE UNITED STATES AND PROPOSED PATENT LEGISLATION

By Edwin J. Prindle

ABSTRACT OF PAPER

The decision of the Supreme Court in the Mimeograph case, sustaining the right of the patentee to require the purchaser of the machine to buy of the patentee ink and paper for use on it, has resulted in the introduction of a large number of bills in Congress, with a view to cutting down the patentee's monopoly. This paper explains the Mimeograph decision and, incidentally, the general nature of a patent and the monopoly which it grants, and explains the Bath Tub case recently decided by the Supreme Court; the price-restriction case of Bauer vs. O'Donnell, now before that Court for decision; the relation of the patent law to the Sherman act; and the general nature of the proposed legislation and its effect on the patent law, and upon manufacturers and inventors.

THE PRESENT CONDITION OF THE PATENT LAW

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By Edwin J. Prindle, New York City

Member of the Society

The Supreme Court of the United States on March 11, 1912, rendered a decision in the case of Henry vs. Dick which has been generally misunderstood and has aroused clamor for changes in the patent law of great public importance. The court sustained the right of a patentee to dictate conditions under which his patented machine could be used, and the same reasoning would maintain his right to fix prices below which his product could not be sold. To many laymen and some lawyers the decision seems contrary to the Sherman anti-trust act.

2 The Supreme Court has also since rendered a decision in what is known as the Bath Tub case, which bears on the relation of the patent law to the Sherman act, and tends to mark out the line between them.

3 A case known as Bauer vs. O'Donnell is now before the Supreme Court for decision on the right of the patentee to dictate the price at which his article may be sold by the retailer.

4 There is a general misunderstanding of the issues involved in Henry vs. Dick, and most men, upon hearing an adequate explanation of what the decision means, see that the rights of the public are not in any manner jeopardized by it. In consequence of this situation, and particularly of the decision in the case of Henry vs. Dick, many bills have been introduced in Congress seeking to modify the patent law in fundamental particulars, and not only to cut down the monopoly of the inventor but

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to put his property at a great disadvantage compared with unpatented property, and the situation is a serious one. It is the object of the present paper to explain the meaning and effect of the decisions in question and of the proposed legislation.

HENRY VS. DICK

5 The case of Henry vs. Dick will be discussed first and will be treated with what might otherwise appear to be disproportionate fullness because it will be used as a basis for explaining most of the principles involved in the controversy.

6 Dick invented a mimeograph or copying machine and patented it. He sold it with this label prominently displayed on the machine:

LICENSE RESTRICTION

This machine is sold by the A. B. Dick Company with the license restriction that it may be used only with the stencil paper, ink and other supplies made by the A. B. Dick Company, Chicago, U. S. A.

7 A Miss Skou bought one of the Dick machines and Sidney Henry, the defendant in this case, sold her a can of ink, intending that the ink should be used on the Dick machine, and knowing that such use would be in violation of the notice on the machine. The Supreme Court held that Miss Skou had no right to use the machine with ink bought from any one else than the Dick company, and that Henry, in intentionally aiding her to violate her obligations to the Dick company, was a contributory infringer and was properly enjoined from a repetition of his act.

REASONS FOR ENACTING THE PATENT LAW

8 Before the patent law was enacted, the only way in which an inventor could obtain a return from his invention was by keeping it secret; otherwise a competitor might copy the invention and without any overhead expense or initial investment of capital, as compared with the inventor, reap the benefit of perhaps a large expenditure of time and money made in producing and perfecting the invention. As a result, comparatively few inventions came into existence, and those that did were jealously kept secret so far as possible. Workmen were sworn to secrecy, and the inventions were practised only under lock and key and with every effort to prevent their leaking out.

9 Under these circumstances, the public could not get the full benefit of the invention, because the inventor could not manufacture in as large quantities nor as cheaply as if it had been unnecessary to observe these precautions. If there was an ingredient or a formula or some particular step in a process which one person could take care of in the manufacturing, the inventor was likely to keep the knowledge of that one point entirely to himself, intending, usually, to disclose it to some one else when death approached, but as death often comes without warning, the inventor often died without disclosing the secret, so that the invention was lost to the world forever unless it should be rediscovered by some one else. There are not a few of these lost secrets or "lost arts."

10 When the patent law was enacted it said, in effect, to the inventor: "If you will give us (the public) a complete disclosure of your invention so that anyone skilled in the art can practise it, we will give you an absolute monoply of this invention for seventeen years. This will enable you to practise the invention without fear that it will be stolen, so that you can get the full harvest from it during the life of your patent, and we will have the benefit of it forever afterwards." The fathers of our country regarded this law as so important that they made provision for it in the Constitution itself. The first patents were granted by a board consisting of George Washington, his secretary of state and his attorney general, after a personal hearing of the inventor, and they personally signed these patents.

WHAT A PATENT GRANTS

11 The patent law simply says to the inventor: "We will give you a clear field to make money out of your invention if you can. Whether you ever make a dollar or not depends upon your own ability and industry in making, using and selling your patented invention." The patent does not cost the public one cent, for the inventor even pays all the expenses of the Government in granting the patent.

12 The patent, therefore, grants to the inventor the right to exclude or enjoin all others from any making, using or selling of his patented invention. He may either get his return by keeping the market wholly to himself and manufacturing and selling the invention, or he may sell to others immunity from

the injunctions to which the inventor is entitled by his patent. In other words, he may sell licenses or other forms of grant under his patent, which means, in effect, that "For the consideration which you pay me, I give up my right to exclude you from my monopoly to the extent we agree upon."

13 The patentee is under no obligation either to manufacture the patented invention himself or to let anyone else manufacture it. The Supreme Court has said, by a unanimous decision in the Paper Bag case, that it is the patentee's right to sit still during the life of his patent and neither manufacture himself nor let anyone else manufacture. This exclusive monopoly is the reasonable price which the public agreed to pay for the making and disclosure of the invention, and during the life of the patent it must let the invention alone. When the term of the patent has expired, the public will have an unrestricted right to use the invention of which, but for the inventor, it would never have known.

DICK'S RIGHTS UNDER HIS PATENT

14 Dick, then, was at liberty to prevent anyone from using his patented machine during the life of his patent. That would have been to exercise his *entire* right of exclusion. He did not choose to do this, however. He might have sold his machine outright for a sum of money representing the entire profit to which he thought he was entitled for his invention. If he had charged more than the public thought the machine was worth, he would have made no sales. The public would have been under no obligations to purchase the machine. Dick found that his machine did not work successfully with every kind of ink, nor with every kind of stencil paper, but that it worked much better with a certain kind of ink, and with stencil paper having certain qualities. It was to Dick's interest that the machine should do good work, in order that he might sell a large number of machines, and it was also to the interest of the public that the machines should not be disappointing to the users. Dick considered that if he only *partially* released each machine from his power of injunction, to the extent of requiring that the ink and stencil paper be bought of him, he would be able to make certain that the users of it had the right sort of ink and paper. He would also be able to sell the machine for a comparatively low price at the outset and add his profit a little at a time to the

ink and stencil paper. In this way the initial cost would not be burdensome, and the price that a person paid for a machine would be in proportion to the amount of use which he had of it; that is, in proportion to the amount of ink and stencil paper which he used upon it.

15 Another case in which the Supreme Court upheld the right of the patentee to say that his patented article should only be used under certain conditions is the Cotton Tie case, in which case the court decided that the patentee of a buckle for fastening bales of cotton could lawfully impose the condition on the purchaser that the buckle should be used only once. The patentee stamped on each buckle the words "licensed to use once only." In removing the buckle from the bale it was necessary to cut the buckle. A rival manufacturer bought the buckles after they had thus been used and cut, and repaired them and offered them for sale again. He, like Henry, in the Dick case, was restrained.

16 As Dick, under the Paper Bag decision, had the power to say to the public, "You shall not use my machine at all during the life of my patent," it was reasonable that he should have the power to say, "You may use it, but only on certain conditions," providing the purchaser agreed to those conditions at the time he purchased the machine.

17 *A sale of a patented article without conditions puts it forever beyond the control of the patentee.* It has been repeatedly decided that if an inventor once sells a machine without any conditions attached to the sale, that machine passes beyond, or without, the monopoly, and he can never again exercise any control over it whatever. It is a misunderstanding on this point that has caused much of the cry against the decision in this case. If Miss Skou had bought the machine without any license restriction on it, or without such restriction being called to her notice in any way, she could have used it with any ink she chose without interference from Dick. When she bought the machine with the license restriction displayed on it in such a way that she could not fail to notice it, she impliedly consented to the conditions of that license restriction and bought the machine subject to them. Having bought the machine with this *qualified* title to it, she could not object to Dick's wanting the bargain lived up to. The physical machine belonged to her; that is, the metal, the screws, and other parts, and she was at liberty to make any

use of them which did not infringe the monopoly granted by the patent, but she was not at liberty to trespass upon the portion of the monopoly which Dick reserved to himself when he sold her the machine; namely, the right to use that machine with other inks and other stencil papers than those made by Dick.

18 Many people think that this decision gives the patentee the right to pursue the purchaser of his patented machine and interfere with its use or sale after he has received his full pay for it, but that is not so. If he once sold the machine free from his monopoly, it would be gone forever so far as he was concerned. It is only when he sells it with the distinct understanding, either expressly agreed to by the purchaser or impliedly agreed to, because the understanding is stated in a notice fixed on the patented article so prominently that it cannot be reasonably overlooked, that he can exercise any control whatever over the patented article in the user's hands. It is not conceivable that an injunction would be granted by any court in a case where the printed notice on the patented article was not so prominently displayed as to be certain to attract the purchaser's attention.

19 Ex-President Taft, when on the bench, participated in a decision which upheld rights similar to those in the Dick machine. This related to machines for fastening buttons on shoes, the machines being sold under the license restriction that the purchaser should use them only with button fasteners bought of the manufacturers, as follows:

CONDITIONS OF SALE

This machine is sold and purchased to use only with fasteners made by the Peninsula Novelty Company to whom the title to said machine reverts upon violation of this contract of sale.

20 These button fasteners were not patented, and the manufacturers took their profit on the machine chiefly through charging a larger price for them than the market price. The payment for the machine was entirely inadequate, considered by itself, to compensate even for the machine. The court said that the button fasteners were, in effect, counters by which the payment for the machines were measured. This case was not appealed to the Supreme Court, but that court referred to it in a later case as a "leading case," which is a strong expression of legal approval.

21 *Henry could not have been enjoined unless he knew that his ink was to be used on the Dick machine.* The injunction was issued against Henry in this case only because he intentionally helped to bring about a violation of the rights reserved by Dick and consented to by Miss Skou under Dick's implied contract with Miss Skou. It has been repeatedly held that one who intentionally helps another to infringe a patent can be enjoined as a contributory infringer. This is precisely what Henry did. He sold the ink to Miss Skou, knowing that she was under an implied contract not to use the ink on the machine, and Henry intended that she should use it on the machine. If Henry had merely sold Miss Skou the ink, having no reason to suppose that she was going to use it in violation of a license, he would not have been an infringer and could not have been enjoined. There is absolutely no foundation for any fear that this decision would render any dealer liable to injunction who sells ink, or any other supply, without any reason to suppose it is going to be used in violation of a patent.

22 *The decision does not give Dick a monopoly of ink.* There has been fear on the part of many people that the effect of decisions like the Dick decision and the button fastener machine decision would be to give the patentee a monopoly of unpatented products; for instance, in the one case of inks, and in the other case of unpatented button fasteners. This is erroneous, however, as the public is just as free to buy ink for any other purpose than for use on the Dick machine as it ever was, and so, also, with the button fasteners. It is only when ink is bought or sold from others than Dick for the specific purpose of use with the Dick machine that Dick can interfere under his patent. It is impossible that this control over the inks to be used with Dick's machine should affect the price of ink for other purposes. Dick could not control the price of one-tenth of one per cent of all the ink sold in this country, for all of his machines together would not use that amount of ink. Whatever market for ink Dick controlled was of his own creation, by inventing the machine which uses the ink.

THE BAUER VS. O'DONNELL CASE

23 This case is closely connected in principle with the case of Henry vs. Dick. The Bauer Chemical Company manufactures

a food tonic, and sells this tonic with the following label pasted on each package:

> **For sale and use at a retail price not less than one dollar ($1). Any sale in violation of this condition, or use when so sold, will constitute an infringement of our patent, under which [the tonic] is manufactured, and all persons so selling or using package or contents will be liable to injunction and damages.**
>
> **A purchase is an acceptance of this condition. All rights revert to the undersigned in the event of violation.**

24 A Washington druggist bought the preparation from the manufacturers and sold it at a price below $1. He also bought it through jobbers and cut the price. Upon his failure to abide by promises that he would not cut the prices, the company owning the patent brought suit against him under the patent for an injunction to restrain him from cutting the price and for an accounting of profits and damages. The Court of Appeals for the District of Columbia certified this case to the Supreme Court of the United States for instructions, and the case is now awaiting a hearing by the latter court. This is the first case which has ever brought squarely to the Supreme Court the question of the patentee's right to dictate the price at which his product shall be sold, although the question is involved in a number of other suits now pending in the lower courts, and has been many times decided by the lower courts in this country and in England. The decision of the Supreme Court will, of course, settle the law on this point in the United States.

25 As explained in connection with Henry vs. Dick, the patentee really has three separate monopolies: The right to exclude all others from making, from using, and from selling his invention. These rights, with one very recent exception, have been treated by the lower courts in the United States as separate and distinct and capable of being separately sold. They have also each of them been held to be capable of sale for a limited territory, or for limited times, or limited to special trades or arts.

26 In Henry vs. Dick, the Supreme Court sustained the right of the patentee to prescribe the conditions under which his patented product should be used. In the Bauer vs. O'Donnell case, the question before the Supreme Court will be whether the patentee can prescribe conditions under which his article can be sold. The question is very important to patentees because the

whole advantage of the patent would be lost in some instances if it were not for this power over the sale of the article.

THE DICK DECISION NOT IN CONFLICT WITH THE SHERMAN ACT

27 While this right of the patentee to maintain the prices of his patented article, and Dick's control over the ink, may appear a violation of the Sherman act, in reality they are not. The Supreme Court has expressly decided that the control of the patentee over his patented article is not a violation of the Sherman act. The reasons will be apparent upon considering the purposes of the two acts. The patent act was for the purpose of inducing inventors to make inventions and to put the public in possession of a working knowledge of them, and the sole inducement was a monopoly granted to the patentee for a limited time to make money out of the invention, if he could.

28 On the other hand, the Sherman act was for the preservation of the rights of the public in trade which it already possessed and to prevent raising by a monopoly the prices of articles in which the public already had a right to trade.

29 The patent statute was for the purpose of bringing into existence trade in articles which never had and perhaps never would have existed but for the monopoly offered by the public as a reward to the inventor for inventing them, while the Sherman act was to preserve to the public free competition in trade which already existed and belonged to the public. The patentee takes no rights from the public when he restricts the conditions of use or price of sale of patented inventions. He is but dealing with his own. He can suppress it if he wishes. The public can have it without price simply by waiting until the patent has expired, but the patentee has a contract (his patent) giving him the exclusive right until that time. The public never had any right to sell ink for use with Dick's machine, for the machine never existed until he invented it. Therefore he has taken nothing away from the public which belongs to it, and there is nothing for the Sherman act to operate upon.

30 The control of the patentee over the conditions of use or sale of his patented article is not so absolute as it might seem. The only way in which he can get return from his patented article is by inducing the public to use it. If, then, he imposes restrictions which are too burdensome or which take away the

advantage of the public in using the article, he cuts down the sales which he might otherwise make. This fact alone puts a limit on the restrictions which the patentee will impose on his patented article.

THE BATH TUB DECISION

31 The patent involved in the bath tub decision was one relating to an implement for shaking sand, more or less automatically, on a red hot iron bath tub for the purpose of forming an enamel on the bath tub. Under the guise of licensing manufacturers under the patent to use the implement, a *combination of manufacturers* was effected, which prescribed prices and conditions under which bath tubs were to be sold. The *association* forbade the selling of " seconds " or bath tubs which were in any manner imperfect, and not only fixed the prices, but imposed penalties for selling below those prices. The *association* also provided a jobber's license agreement which he had to execute before he could purchase the licensed sanitary enamelware. Various zones were established which were to be preserved to specified parties. There were other regulations too numerous to mention.

32 The Supreme Court in the Bath Tub case held, in effect, that the manufacturers had formed a combination in restraint of trade and in violation of the Sherman act, and that the patent was a mere cloak. The vital objection was that the manufacturers formed a combination *between themselves.* The court did not decide that the patentee could not have lawfully imposed the same conditions separately upon each manufacturer as a license if there was no combination and conspiracy between the manufacturers. If the manufacturers had all had their relations directly with the patentee and there had been no combination between themselves, so far as the Supreme Court decided, it would not have been objectionable. The court did not decide whether or not it was lawful to regulate the price of unpatented bath tubs under a patent for a patented implement used in the manufacture of the bath tubs.

THE PROPOSED PATENT LAW REVISION

33 Following the Dick decision a flood of bills was introduced into Congress seeking to amend the patent statute to cut down the inventor's monopoly and greatly restrict his control over the property which he had created. The theory of the framers of these bills was that this property was going to come into exist-

ence anyhow, no matter how little the inducement, and it was perfectly safe to regulate it to any extent, any monopoly which remained in the inventor being mistakenly thought to be a free gift from the public instead of an inducement, without which the invention could not come into existence.

34 The principal bill, which was recommended by a majority (only) of the Patent Committee of the House of Representatives, contains almost every negative amendment of the patent law that anybody has suggested. This bill has not yet passed either house of Congress. The three principal provisions of the bill are:

a Compulsory licenses which are to be obtainable from a Federal District Court by anyone who can establish that the owner of the patent (not being the original inventor) has purchased the patent for the purpose of suppression. The Patent Committee of the House of Representatives was unable to point out any tangible instance of such patent suppression, and only an average of one to six out of about sixty witnesses who testified before the Committee, or who presented communications on the subject, was in favor of any such provision. A complete discussion of the provision would be beyond the scope of this paper, but a few of the main objections may be stated as follows:

If this amendment were made, no manufacturer would dare to patent or disclose anything but the preferred form of the invention, because inferior forms which he might patent and disclose could be manufactured by others, under the compulsory license, in competition with his preferred form. This might destroy the effect of a generic or parent patent which was parent to the children. It is unlikely that a court would require the licensee to pay a price commensurate with the expense to the manufacturer of the cost of developing the preferred form, so that the manufacturer would be at a disadvantage. The manufacturer could not afford to improve his product, because the moment he began to manufacture the improved form, somebody would demand the right to manufacture the poorer, original form. No manufacturer could afford to own more than one patent in a given

line. The constant danger of litigation to compel a license would make patents much less desirable property than they are today, and greatly decrease their value. Thus the effect of the compulsory license would be to discourage invention instead of to encourage it. It is believed that there are very few instances of suppressing the best invention in a particular line, and so long as a manufacturer furnishes the public with the best form of the invention, it is to the benefit of the public to give him a monopoly during the years which it will take to establish the article thoroughly in the trade.

b The bill also forbids license restrictions as to the manufacture, use or sale of his patented product by taking away practically all power to enforce any such restrictions, even though the purchaser agreed to them in order to induce the purchase. This again would very greatly lessen the value of patents and consequently reduce the incentive to make inventions, so that inventions would not be made to the same extent as today. The bill forbids the patentee the control over his property which largely resides in the owner of unpatented property. It puts the inventor at a disadvantage as compared with the owners of other property.

c The bill also provides that a presumption that the Sherman anti-trust act has been violated shall be conclusively presumed, when any one of a large number of the most common business transactions is entered into in connection with patented property, regardless of any surrounding circumstances. If the patentee attempts to restrict the price at which the article may be resold; if he attempts to compel a purchaser to buy an unpatented article from him with the patented article (such as in the Dick case); if he purchases other patents with a view to preventing competition with his patented article; if he attempts to control the territory in which his article shall be sold; or to sell to one person on conditions less favorable than to another; or to do business under any other name than his own, or that of his firm or corpora-

tion, he is conclusively presumed to have violated the Sherman anti-trust act, and anyone who has been injured may bring a suit within three years after he has been damaged and recover threefold damages, the costs of the suit, and his attorney's fees. Moreover, the patent may be declared forfeited and the owner of the patent may be fined $5000 and imprisoned for a year. In other words, the patentee is tremendously worse off with his valuable property, which he has created with his own brain, and which is a great benefit to the public, than the owner of any other kind of property.

35 *There is grave danger in putting the knife to the inventor's reward.* The temptation may be strong to prohibit the patentee from exercising such control over the sale or use of his patented article as the Dick decision gives. It looks so easy simply to amend the patent statute and cut down the extent of the monopoly granted by the patent. It seems as though the public might just as well have this advantage as not. But, as a practical matter, it is to be considered whether the public would not lose more than it would gain. Taken as a whole, the price is a mere bagatelle which the public has paid for the inventions that have been produced solely as a result of the patent statute. The patents have not cost the public a single penny, for the inventors have, by their fees, paid all the cost to the Government of granting them. On the other hand, the price paid by inventors in the cost of experiments, and in the time involved and the energy expended, has been beyond all calculation.

36 I know of one machine in the shoemaking art upon which over $500,000 was expended before it was considered perfect enough to put on the market. Instances are not at all rare where $100,000 or more has been expended in developing an invention. Most of the large progressive manufacturing concerns of the United States maintain a corps of inventors who are seeking to improve their products and cheapen the cost of manufacture, all of which goes into the general fund of human knowledge, and, after the short period of the patent has passed, is forever at the service of anyone who wishes to use it. Not only have the patented inventions cost the public absolutely nothing, but the inventor will get no return whatever, unless he can succeed

in making money out of the invention. This means that he must *further* serve the public by supplying it with the patented product in order that he may have any return.

37 *The patent statute has been a cardinal factor in the development of our country.* No one statute in all history has made for the material advancement of mankind to an extent at all comparable with the patent statute. Man's hands have been multiplied and made more efficient and skilful by the inventions produced as a result of the patent statute, so that the average man today lives with a degree of comfort, a power of communication and transportation, a quantity of reading matter, a variety of pleasures and a control over nature which were unobtainable by the man of 100 years ago, regardless of his wealth.

38 Let us take the tools and appliances which the inventor has supplied the farmer as a typical instance. In 1791, the best plow was a wooden structure shod with iron, and it was so imperfect that but an acre of land could be plowed in a day, and even then the soil was not much more than scratched. The plow had hardly been improved at all in 40 centuries. Now, a steel plow turns up the ground so much deeper and better that a much larger crop is grown, and several times as much work can be done in a day with the ordinary one-horse plow as with the old form, while with the steam-driven gang plow 30 times as much work can be done in a day. In George Washington's day thrashing was done by the use of a flail, producing about five bushels of wheat a day. Now, a steam thresher can thresh a thousand bushels in the same time, and there are even steam-propelled harvesting machines which cut a swath 26 ft. wide through a field of wheat, and thresh, clean and sack the grain at the rate of three bushels a minute, and yet but seven men are required to run such a machine. All these changes have come about as the result of the American patent law, and practically within the space of less than a century. If there were time to review the similar changes in other fields of industry due to our patent law, it would read like a fairy tale. Many arts and industries owe their very creation and existence to the patent law.

39 *The inventor's reward should not be disturbed, but, instead, the patent law should be simplified and strengthened.* With the bargain already so tremendously one-sided in favor of the public, and with the burden already so heavy on the inventor, we should

be exceedingly slow to lessen the inducement to the inventor to continue his work. At the very longest, his monopoly can exist but 17 years. A considerable part of this period is usually taken up in getting the invention successfully upon the market, even in the case of the most successful inventions. The necessity he is under to sell his product is a natural limitation on the conditions which he may impose. At the most, the public need only wait the 17 years in order to have perfect freedom to make, use and sell the invention.

40 It would be unwise, in the extreme, to jeopardize the effective continuance of this most advantageous work on the part of the inventor by cutting down in any way the return to him which, in any case, costs the public nothing, and is a trifle compared with the benefit to mankind. The effect of any present change in the patent laws would not become evident for a considerable length of time, and it might take many years to recover the lost ground, not only in the degree to which we have fallen behind invention abroad, but in the loss of inventive power due to incentive to develop it.

41 The patent law needs changes, but changes to build it up, not to tear it down. The Patent Office should have a sufficient force of adequately paid examiners so that it can make practically certain it is issuing patents only for inventions which are new. The procedure of adjudicating a patent should be made cheaper, simpler and shorter. For that purpose there should be enough judges so that patent cases may be quickly tried by testimony taken orally in the presence of the judge, instead of by printed records of testimony taken slowly and expensively before a master and then read before a judge. The fees now payable to the clerks of the courts should be reduced to only a fair compensation for the services performed. And a single court of patent appeals should be established, instead of the present intolerable system of nine separate circuit courts of appeals, each having equal and independent jurisdiction in their own circuits of every patent.

THE V-NOTCH WEIR METHOD OF MEASUREMENT

By D. Robert Yarnall, Published in The Journal for October 1912

ABSTRACT OF PAPER

This paper explains the V-notch weir method of measurement and a convenient form of apparatus, the Lea recorder, which can be used for recording graphically and continuously and with a high degree of accuracy rates of flow over V-notches and other weirs. It is shown why the V-notch is the most accurate and convenient form of weir for general testing purposes.

The paper also gives details of tests made with the apparatus measuring hot boiler feedwater at the Dartmouth College power plant during both winter and summer load conditions. The results of these tests show the great accuracy of the V-notch at low rates of flow as well as high.

Results of additional tests recently made in Philadelphia and near New York are given which together with the Dartmouth College tests show that the V-notch method of measurement gives results at high, intermediate and low rates of flow which can be relied upon to within one per cent.

DISCUSSION

W. S. Giele told of tests made under his supervision by the Harrison Boiler Works on a Cochrane independent meter which was equipped with a Lea recorder; these tests were made because at that time there were in this country no data available in connection with meters of large capacity. As to the correction for temperature of the water during the progress of the test, the speaker stated that no such correction is made because the V-notch is a volume machine, and the transformation from volume to weight is made in the cam shown in Fig. 3. But there is a temperature correction necessary between the temperature for which the cam is cut, and the temperature at which the measuring tanks were calibrated (in this case 3.5 per cent). It is a peculiar fact that this kind of instrument is to a large extent self-compensating as the submergence of the

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float varies with the density of the water, and thus in a measure compensates for the variation in the volume of the water going through the notch. In some tests made by the speaker the error was as little as ½ of 1 per cent.

The V-notch weir referred to by Mr. Yarnall is not in itself new, its formula having been investigated and developed by Thompson in 1858 and also investigated with more refined apparatus by Barr in 1907. The more general adoption of the V-notch weir has been handicapped by the lack of a recording apparatus sufficiently delicate to take advantage of the superior accuracy of the V-notch weir, particularly at low rates of flow and Mr. Yarnall's paper describes a recording apparatus which is intended to meet this need.

J. H. Browne described how the hook gage was applied to obviate the large expense and time necessary to test the type of meter used in the Dartmouth College tests. In Table 2 can be seen a hand-hole on the front side of the V-notch. In conjunction with the engineer at the plant the speaker inserted a hook gage in this hand-hole sufficiently far back from the V-notch so that it would not be disturbed by the flow of water, and took observations on the hook gage every three minutes for one hour and thirty minutes. Simultaneously the engineer took observations on the vertical scale in the case of the recorder. These observations were found to coincide with each other to the third decimal, in inches, that is to 0.001 in. By this and similar methods it was also proved that the meter is correct over a very fluctuating flow.

Fred. N. Connet thought that a wrong inference would result from the statement in Par. 13, that the accuracy of a venturi meter or pitot tube depends upon *velocity changes* and that fluctuations in velocity therefore impair the accuracy. While it is true that the differential pressure at the two points in a venturi tube is due to the difference in velocity at those two points, it is not true that it is due to any changing or varying in that velocity. Any inaccuracy due to a changing or fluctuating velocity is just as sure to apply to a V-notch as it is to a venturi or pitot tube. In the device described by Mr. Yarnall, the large tank exerts a steadying effect upon the velocity of the water and credit should not be given to the notch but to the tank. A tank

used in series with a venturi tube gives exactly the same beneficial results, although such a tank is seldom required.

When installing a boiler feed meter of any type whatever it is customary to select one having a maximum capacity about twice the ordinary load. It is desirable therefore to have the greatest accuracy of the meter apply to rates which are approximately one-half the maximum capacity. The V-notch is more accurate for low velocities because there is a considerable movement of the float corresponding to fluctuations in the flow at that point. As the water, however, rises in the V-notch, the width of the weir becomes greater and the float movement corresponding to variations in velocity becomes less and less. As the paper states, a 90 deg. V-notch weir with a capacity of 100,000 lb. per hr. has a maximum float movement of 6 in., and at a 50,000 lb. rate the float movement is about 4½ in. At this rate a variation of 1/16 in. in the float elevation changes the meter readings about 2000 lb. per hr., equal to about 4 per cent of the nominal capacity. The error due to a departure of the float from its intended position will be relatively smaller in meters of greater capacity, and vice versa, but the capacity mentioned probably represents an average of the boiler feed meters in use in this country. In the venturi meter the total float movement is about 22 in. for meters of all capacities, and when running at half speed a variation of 1/16 in., which is more than would probably occur, corresponds to only 3/10 of one per cent of the nominal capacity.

THE AUTHOR said that he had been working for some time on a compensating float of a varying section such that, should the density of the water change owing to changes in the temperature, it would correct exactly by weight for those changes due to its being immersed more or less. When a V-notch meter is used for measuring hot water, as the temperature rises the buoyancy decreases, and the float which is the actuating means for the recorder drops a little in the water. Over a range of about 50 deg. it compensates very closely indeed. The float used is a double conical float, with a 3-in. straight barrel. It was found that with the float so formed an almost complete compensation for the changes of temperature could be obtained. The tests in this direction are not finished yet.

The test referred to by Mr. Giele was made on a Lea V-notch

recorder having a maximum capacity of 300,000 lb. per hr. It is interesting to note by referring to the data of this test in the paper that the compensation for changes in temperature was almost exact. The only correction necessary was for the temperature at which the test was run, namely 73 deg., while the cam of the Lea recorder was cut to measure water at 212 deg. This correction was predetermined from the known formula of the flow, which formula was used in plotting the cam for the drum.

INCREASE OF BORE OF HIGH-SPEED WHEELS BY CENTRIFUGAL STRESSES

WITH FORMULAE FOR FORCE AND SHRINK FITS

By Sanford A. Moss, Published in The Journal for September 1912

ABSTRACT OF PAPER

Unless proper precautions are taken, a high-speed turbine wheel expands at the hub a sufficient amount to cause an appreciable increase in the bore so as to make the wheel slightly loose upon the shaft, soon causing distress.

There is given in the paper a general discussion of stresses in a rotating wheel; a mathematical method for computation of the increase in bore of a rotating wheel due to centrifugal stresses; an investigation of the actual numerical value of the increase of bore under various practical conditions; an experiment giving an actual measurement of the increase in bore of a wheel at high speeds, showing close agreement with computed values; a description of methods of preventing damage due to the increase of bore by using large amounts of force fit; and a mathematical treatment of force fits.

The increase of circumference of the bore is proportional to the original circumference and the tangential stress and inversely as the modulus of elasticity. In the experiments the readings showed that the bore expanded at each speed an amount almost exactly equal to the computed values.

For a wheel with 12 in. bore and 30,000 lb. maximum stress, which is permissible with special grades of steel, this increase of bore comes out over 0.01 in., which gives an appreciable loosening of the shaft fit.

A complete treatment of the subject of force and shrink fits based on the maximum shear law is given for the first time so far as known.

When the hub is in place on the shaft, it is expanded by a certain amount and the shaft is also compressed by a considerable amount. The ratio of expansion of the hub to the total force fit is the same for a given wheel and shaft regardless of the amount of the force fit. A curve is given showing values for various cases. Curves are also given showing values of radial stress at the bore of the hub which is also the pressure between hub and shaft, and the maximum effective stress at the bore of the hub which is usually the greatest stress in the

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system. The usual case of a shaft with a comparatively small hole is practically equivalent to a solid shaft for these matters.

For an average case the hub bore expands about 0.6 of the amount of the force fit and for a force fit of one mill per inch of bore the radial stress is about 13,000 lb. per sq. in. and the effective tangential stress is about 27,000 lb. per sq. in. For other amounts of force fit the stresses are in proportion.

For the average case above mentioned the pressure to force the hub on the shaft is about 1560 lb. per in. of bore and per inch of hub length for a force fit of one mill per inch of bore.

DISCUSSION

Richard H. Rice said that the paper showed, first, that the computations made for stresses in wheels running at high speed are correct. The forms of wheels used in turbines and in air compressors and other high-speed machinery are complex, and the analyses for the solution of the stresses and strains in such wheels are also complex. It is gratifying to find that actual measurements on the many wheels measured confirm accurately our computations and show that the formulae are adequate for the purpose.

The paper also shows that wheels running at high speeds do expand in the bore, although some little question has been raised as to this, and the amount of expansion can be accurately computed. It also shows that such expansion can be adequately taken care of and that it is a matter of no importance whatsoever, so long as the designer knows the amount of expansion so that he can provide a forced fit somewhat greater than the expansion.

Wm. H. Kenerson said that it would help in an interpretation of the results of the tests described in the paper to know something of the length and character of the end of the little piston pieces running from the sleeve in the shaft to the hole whose diameter is being measured, and that he hoped the author would tell something about this, so that an idea might be gained of how much that distance changes when the shaft is going at high speed.

Mr. Rice replied to Mr. Kenerson's question that that point is provided for in the preliminary calibrations where the readings were calibrated by working on sleeves of known diameter. In reply to a further question he added that the sleeves provided were of such small diameter their expansion was negligible.

WM. KENT asked how Poisson's ratio had been determined, and said that while he had seen many figures published of Poisson's ratio, he had never seen a statement of how it was measured. He desired to know whether there were any American experiments on the subject to determine Poisson's ratio.

ELMER A. SPERRY wrote that he was personally interested in the paper, as he had himself pursued similar investigations especially upon the subjects treated in the first part of the paper, and apparently had carried them even further than the author. As a basis of two large gyroscopes which together constitute by far the most powerful gyroscope plant ever undertaken, he had two 50-in. wheels weighing on the order of 5000 lb. each, upon which rupturing tests, so called, were run. The real object of the tests was (*a*) to determine the integrity of the specific strength of the wheels; (*b*) to check them up with the elastic limit as indicated by a number of test bars taken from wheels; and (*c*), the most important, to make the interior portion of these wheels flow in such a way that in their natural state the whole interior of the wheel would be under pressure before finished boring. The speed was calculated at which the central part of the bore of the wheels, the general shape of the hubs of which were similar to Fig. 2 of the paper, would take a permanent set to the extent of several thousandths of an inch. The wheels were then put to this speed and the bore searched carefully for evidences of the permanent set. In each case it was found that this not only existed but was practically in accord with the quantities calculated. This was also an assurance that the wheels were solid and reliable in this critical zone or central region. Experience with these wheels would corroborate the statements made in the paper, which the writer looks upon as an extremely valuable and reliable contribution to the knowledge on the subject.

THE AUTHOR. As Mr. Rice has already stated, Mr. Kenerson's point in regard to the validity of the measurements at high speeds was covered by the calibrating sleeve tests discussed in Par. 22. As stated, this sleeve had two different bore diameters, each being accurately known. The sleeve was a thin ring so that its increase of bore at full speed was very small and could be accurately computed. The amount was 0.0012 in. The increase of the bore

TABLE 2 VALUES OF POISSON'S RATIO (RATIO OF CROSS CONTRACTION TO DIRECT EXTENSION PRODUCED BY A SIMPLE TENSION)

Experimenter	Reference	Material	Young's Modulus	Poisson's Ratio	Method	Measurement
Wertheim	Annales de Chimie et de Phisique. ser. 3, vol. 23, 1848.	brass		0.333	Tube closed at both ends subjected to longitudinal tension	Increase in volume of interior of tube and longitudinal extension
Wertheim	Annales de Chimie et de Phisique, ser. 3, vol. 23, 1848.	glass				
Kirchoff	Poggendorff's Annalen, vol. 108, 1859.	steel		0.294	Wire subjected to combined twisting and bending	Twist and transverse deflection
Bauschinger	Der Civilingenieur, 1879	steel		0.284	Bar subjected to tension	Direct measurements of cross contraction and longitudinal extension
Bauschinger	Der Civilingenieur, 1879	steel (bessemer car axle)		0.261		
Bauschinger	Der Civilingenieur, 1879	tin		0.275		
Bauschinger	Der Civilingenieur, 1879	sandstone		0.075 to 0.250		
Amagat	Journal de Physique, 1889	steel	29.60×10^6	0.269	*a* Tube closed at both ends subjected to longitudinal tension	*a* Increase in volume of interior of tube and longitudinal extension
Amagat	Journal de Physique, 1889	brass	15.73×10^6	0.327	*b* Tube closed at both ends subjected to (1) longitudinal tension and (2) to external pressure over its surface	*b* (1) Increase in volume of interior of tube (2) decrease of volume of interior of tube
Amagat	Journal de Physique, 1889	copper	17.82×10^6	0.327		
Amagat	Journal de Physique, 1889	lead	2.28×10^6	0.428		
Mallock	Proceedings Royal Society, vol. 29, 1879	steel		0.253	Rectangular beam bent by couples	Longitudinal and transverse radii of curvature of surface

Mallock	Proceedings Royal Society, vol. 29, 1879	brass		0.325		
Mallock	Proceedings Royal Society, vol. 29, 1879	copper		0.348		
Morrow	Philosophical Magazine, ser. 6, vol. 6, 1903	steel (mild)	30.64×10^6	0.275	Bars subjected to tension	Direct measurement of cross contractions and longitudinal extension
Morrow	Philosophical Magazine, ser. 6, vol. 6, 1903	steel (Sheffield spindle)	29.05×10^6	0.276		
Morrow	Philosophical Magazine, ser. 6, vol. 6, 1903	brass (drawn)	13.70×10^6	0.341		
Morrow	Philosophical Magazine, ser. 6, vol. 6, 1903	copper (drawn)	17.73×10^6	0.327		
Schellens	Thesis M. I. T. 1911	steel (mild structural)	29.97×10^6	0.282	Bars jacketed with mercury	Increase in volume of mercury jacket and longitudinal extension
Schellens	Thesis M. I. T. 1911	steel (high carbon tool)	29.43×10^6	0.292		
Howard	Tests of Metals, Watertown Arsenal	steel				

shown by the instrument agreed exactly with this, showing that there was no compression of the pistons by centrifugal force, indentations of the wheel bore by the piston ends or other unlooked for effects at high speeds. The decrease in length of the pistons due to centrifugal force was computed and found to be absolutely insignificant. The ends of the pistons were rounded and carefully hardened.

In regard to Poisson's ratio there is but one published set of American experiments so far as I know; the matter has been completely settled by many European experiments, however. Through the kindness of Mr. C. A. Schellens I am able to append Table 2 giving the principal references in this matter.

EFFICIENT PRODUCTION OF CYLINDRICAL WORK

By C. H. Norton, Published in The Journal for January

ABSTRACT OF PAPER

Early grinding machines were designed for the purpose of producing a higher degree of refinement than was possible with the lathe, both being used as tools of refinement. Later developments show that the highest efficiency is secured in the great majority of cases by using the lathe solely as a roughing tool, transferring the entire responsibility for refinement to the grinding machine.

The process of roughing is not to be considered in the usual sense of turning to a few thousandths of an inch over the finished size, since this involves an element of refinement and loss of time. The workman at the lathe should use the coarsest feeds possible without regard to finish, calipering the work at the beginning of a cut only, where the tool should be fed by hand for a short distance for this purpose. While a piece roughed out in this manner may require a longer time for grinding than if roughed out more carefully with a certain degree of refinement, the combined time for lathe and grinding machine will be less than if part of the refinement was done by the lathe.

Several examples are quoted by the author of work which has been ground in accordance with the principles outlined. It is held that lathe departments and grinding departments should be conducted under one head, instead of separately as is usually the case, to avoid the tendency of the lathe department to consider its work as a finished product, and of the grinding department to insist on careful turning in order to make a better showing of time required for grinding.

DISCUSSION

R. H. Rice said that in his opinion one of the most important suggestions made in the paper is that the lathe and grinding departments should be one and the same. As soon as this idea is well inculcated in our machine shops, the full benefit of the point which Mr. Norton has suggested will be secured.

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G. I. Alden suggested that in the author's paper is outlined a field for the efficiency engineer which is in many respects perhaps the richest field that could be found, unsurpassed in opportunity.

William Kent stated that efficiency engineers are asking for tabulated data on matters of this kind. They would like, for example, to know the time required for turning and grinding a cylinder of a given size and under given conditions. Such information is too valuable to be hidden in the text of papers and he suggested that where possible an appendix be added to such papers, giving information in tabular form, so that they could be compared with data of the same kind appearing in other papers.

H. P. Fairfield. Mr. Norton's paper is of peculiar interest to me because of a series of tests recently made under my direct supervision in the interests of the Worcester Polytechnic Institute.

The tests were made in a Worcester shop and the aim was to determine in what manner and to what extent the lathe could best be used as a "preparing" machine for cylindrical work finished in the grinding machine. Mr. Norton's remark made in my presence, that a piece of cylindrical work properly prepared for effective grinding should "look like a storm at sea" led to making the tests. The work selected was a lot of forgings to be finished as spindles for heavy machine tools, also a lot of comparatively long and slender shaftings. The lathe and the grinding machine were in these tests considered as a producing unit and worked as such. The first cost of each machine was noted, the power necessary to drive each machine measured and rated, the price paid the operator was charged to each machine and tabulated in the results as was the cost and wear of the cutting tools. The work had the usual amount of excess metal to be removed and the problem assumed the form of a direct question, what is the method of least final cost for removing the excess of stock and what part shall each machine assume in doing the work.

In the case of the forgings the results showed that a certain excess of stock could be removed in the engine lathe with a lesser final cost, using the lathe purely as a roughing out machine, tak-

ing coarse feeds and whatever cutting speeds the cutting tools would stand without excessively rapid dulling of the cutting edges. In the case of the longer and more slender shafts it was in some cases found that they could be roughed out and finished at a lesser final cost in the grinding machine without previous lathe operations.

The conclusions drawn were that the cylindrical work in most shops could be well classified into a limited number of groups of machine parts arranged according to their weight, form and material. Also, that the lathes and grinding machines should be arranged as a production unit and treated in all cases as such. Further that each class of parts should receive an accurate time and cost study with the results carefully tabulated and analyzed; that time and cost studies should be frequently made to determine whether or not the classification of parts as arranged was the better one and whether the machines and tools used were the best obtainable for the object sought.

THE AUTHOR. The facts brought out in this paper are the result of 12 years of patient work and experimenting. The majority of metal machine makers still labor under the impression that grinding is an additional operation in the creation of cylindrical work, and that they have simply to turn work as they have always done, allowing something for the grinding machine to grind off. That was not the idea that created the modern cylindrical grinding machine, although it was the idea that created the original cylindrical grinding machine. The modern grinding machine was originated to assist the lathe in creating cylindrical work and to make the process less expensive than it had been before any grinding was done—not simply to replace filing.

The suggestion of Mr. Kent is a good one. In Par. 35 are given all the details in connection with grinding certain shafts, though not in tabular form. These are what might be called countershafts. The cost of the wheels is given, the wear of the wheels, the cost of power, time and amount of steel removed with every cubic inch of wheel, etc.

THE POWER PLANTS OF TEXTILE MILLS

By John A. Stevens, Published in The Journal for December 1912

ABSTRACT OF PAPER

This paper describes the purposes which should be served by power plants in textile mills.

It calls attention to the individuality of each plant and to the special design and adaptation necessary if it is best to serve its purpose, showing how manufacturing conditions as regards use of low-pressure steam in textile mills make well designed plants for such mills differ from those which would ordinarily be best and most economical for other lines of industry.

The degree to which power plants in textile mills are complicated by use of water power requiring relaying by steam units is discussed, and the effectiveness of electric transmission for securing necessary flexibility under these conditions pointed out.

Several power stations recently installed under the writer's supervision are described and illustrated, the purpose being to call attention to particular features of each plant which illustrate points mentioned in the paper.

A more careful consideration of the advantages which might be secured by groups of mill owners combining to produce power in a single station jointly owned and operated by the group is urged.

DISCUSSION

Charles T. Plunkett inquired whether the author had found it desirable to heat a mill by steam from the receiver of a compound engine. While his plant was fitted up to use steam from the receiver, he had not found it economical to use steam from this source for any purpose except for power. It is not customary, however, in the textile mills, to use steam for heating during the day unless it is very cold. After the machinery is started the requirements to keep the mills warm are very light.

E. W. Thomas asked whether by condensing steam and using the hot water for heating the same economy would result. His

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attention was drawn to the possibilities of heating a plant by using the sprinkler pipes and having a valve to shut off the city supply or to turn it on in case of fire. By using hot water for heating the temperature could be regulated as desired.

CHAS. T. MAIN said that in nearly every one of the woolen and worsted mills with which he had had anything to do in the last few years, the exhaust steam from the power plant had been used almost wholly in the manufacturing processes and that there had been practically no trouble where steam engines were used from oil in the water. By having the water delivered to tanks with an overflow at the top the oil could be skimmed off at the overflow and the water from the bottom used. Steam turbine plants were free from those difficulties because there was no oil in the exhaust steam.

A few years ago Mr. Main was employed as engineer for a large mill which was run entirely by water power, the only engines being small ones connected with the machine. Eighteen thousand tons of coal a year was being burned for manufacturing purposes and the company wanted more water power put in at a great expense. He advised them to save their money and put a part of that into a steam plant and use the exhaust steam for manufacturing purposes. The agent said: "If you say that to the directors you will get fired. You had better keep still."

Mr. Main called attention particularly to the fact that one of the most modern and up-to-date plants where a large amount of steam was used for manufacturing and a small amount for power, took just the reverse view from the writer of this paper as well as himself, and they were going to furnish all of the low-pressure steam direct from the boilers and run the power plant just as economically as they knew how for power only.

CHARLES B. BURLEIGH. The author has touched lightly on the subject of providing a combined steam plant of sufficient capacity to relay any water shortage and stated that it might be late to bring up this matter because many manufacturing plants utilizing water power have already been equipped with relay machinery.

As a matter of record I would like to state that previous to such equipment in the early days of the electric drive, earnest efforts were made by the representatives of the leading manufac-

turers of electrical machinery to bring this very feature to the attention of the hydraulic companies furnishing power to textile mills in New England but for several reasons were unable to interest them.

Many of the older textile mills were located with regard to their proximity to available water-power, thereby in most cases sacrificing many other important considerations, such as light, air, fuel and transportation of goods and numerous other items which have an important bearing upon the cost of the finished product.

The developments of modern genius have made these sacrifices unnecessary in the modern mill. It is today not only possible but would be desirable in large water supplied textile centers, notably Lowell, Lawrence and Manchester, to combine and provide a steam relay of sufficient capacity to supply any deficiency in water-power. This should be located on tide-water where fuel at minimum price and ample low cost water are available for the production of power at minimum cost. That these conditions warrant the most careful consideration of the power consumer is perhaps best evidenced by the fact that many of our large textile mills so located as not to be able to utilize water-power are finding it to their advantage to purchase their entire power from tide-water steam plants.

THE AUTHOR. In reply to Mr. Plunkett, almost the same argument holds for receiver steam taken from an engine as for steam taken from the stage of a turbine. Where there are uses which can be served by steam at low pressure, exhaust or low pressure steam from power units should be used. The changing of molecules of water into steam represents a definite quantity of energy and it makes no difference what kind of steam is used. As long as it is steam, the heat is available for other work.

Two things that a manufacturing company can do to make it easier to stay on earth in a business way are to *avoid operating condensers where heat is required in the mill; and to avoid wasting steam to atmosphere at any time.*

If running entirely non-condensing without a controlling feature there would be a waste from the time when the use for low-pressure steam dropped off, as it usually does, say at half past four in the afternoon. But by the use of the steam turbine there can be, so to speak, 5000 lb. an hour extraction, or if the turbine

is large enough, 60,000 lb. an hour, or such quantity as is required absolutely under control automatically. If, say, 16,000 lb. an hour are wanted for the heating coils and dyehouse when starting in the morning, that quantity can be supplied; and if later, as at half past eleven in the morning, the demand drops off, the supply will be cut down, and at half past four in the afternoon cut off absolutely. These machines will operate to that degree automatically and at a pre-determined pressure on exhaust mains.

In the low pressure stages of some turbines, the revolving parts operate in a vacuum, when all steam possible is being extracted and there is relatively little friction and little additional cost of power when not in use.

The use of controllable exhaust steam makes an absolute and ideal arrangement for operating a plant under best conditions. But let us bear in mind that in arranging a plant of this kind, it must be automatically controlled, the low pressure steam being supplied to meet any demand which may take place at any time.

I have found the range of steam supply from the receiver of an engine to be very limited and a condition as suggested by Mr. Plunkett might exist in some cases since such supply disrupts the balance, governing and operation of the engine, while with the steam turbine of the bleeder type the range may be anything from a very small amount to the entire amount of steam required to operate the turbine non-condensing. One of the best things to do in making arrangements for the power plant is to find out how much steam is to be used for heating the mill and the aggregate demand for low pressure steam in the plant, then the plant can be powered (engined or turbined) to make the total heat balances correct, and the question as to what is most desirable can be calculated to a nicety.

As to another point, it is very desirable that we should have more than one power furnishing unit, engine or turbine, in a manufacturing plant. That is why I have spoken in my paper of relay power, and this relay power might be purchased from the central station or part of the regular power from the central station, cheaper than it could be supplied by condensing units at the plant in question; that is (and starting all over again), the first thing to be determined in any plant is how much heating and manufacturing steam is required. This heating and manufacturing steam should then be supplied from non-condensing power units (including pumping and auxiliary equipment); the

next step is to find whether there is any water-power available at the property or central service power; and the third step to find how this additional power can (over and above the by-product power) be most economically supplied.

In friendly criticism of the condition mentioned by Chas. T. Main of "one of the most modern and up-to-date plants where a large amount of steam was used for manufacturing and a small amount for power," I would state that, for whatever steam is going through their condensers, they are realizing a total thermal efficiency of around 20 per cent, wherein, if they were to reverse the process and make use of their exhaust steam, they might realize a total thermal efficiency of, say, 75 per cent, by running their plant non-condensing.

Mitigating their situation, I might say that sometimes the power plants have to be so located that the companies cannot avail themselves of the use of exhaust steam from power units or the auxiliaries of power units.

I wish further to go on record at this time as stating that the powering and heat balances are of the greatest importance to textile plants and should be taken up by men conversant with the whole subject, if best results are to be expected.

MEASUREMENT OF AIR IN FAN WORK

By Charles H. Treat, Published in The Journal for September 1912

ABSTRACT OF PAPER

The paper discusses the use of the pitot tube for fan testing with particular emphasis on the correct kind of tube to be used. It describes a simple and accurate method of calibration of impact and static orifices, and the instruments to be used in fan testing, as well as the general method and arrangement of the tests. It shows further the derivation of the formula for friction in test pipe, and the method of correcting test results to standard weight air. The paper further contains proofs that the volume discharged from a fan is the same at all densities, other conditions being the same, and indicates the formulae and calculations used in the test, such as the formula for the determination of air horsepower on the discharge and suction side, efficiency of a fan and its speed. Finally, the question of the average velocity of flow in a pipe is discussed.

CLOSURE[1]

The Author. Mr. Carrier brings out a point worthy of particular attention when he places the blame for some of the discordant results of tests on leakage. I would not limit to leakage on the static side only, but anywhere in the connections. It is important that these easily cared for precautions be taken in any testing work and no less so in pitot tube air measurement.

In trying for leaks, pressure is best applied at the pitot tube orifices so that all the piping will be just as it is to be for the test. This method is noted in Par. 24 together with a caution against stopping the connections and drawing over liquid into the rubber tubing. These points should be carefully looked into before every test and it has been the regular practice in work under the writer's charge.

In regard to the detail of arm carrying the pitot tube the only

[1] The discussion was published in the Journal for February.

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objection to one tube inside the other is the smallness of the inner or the largeness of the outer one. In the first case it is difficult to clean the inner tube of dust or of liquid if it comes over from the manometer. In the second case the size of arm is objectionable. A better way of making the arm is to extend it through the measuring pipe at both sides. What slight obstruction there is to smooth flow is then constant for all positions of the pitot tube across the pipe.

I cannot subscribe to Mr. Carrier's statements as to fan efficiencies.

I am grateful to Mr. Moss for putting into the discussion some of the results of his experience in this field.

In regard to setting inclined manometers at zero angle much the best way found is to fill the tubes nearly full of gasolene, leaving only good length air bubbles, corking up the open ends and using the tubes themselves as a level. If they are good this affords means for very accurate setting. After setting the gage the excess gasolene is run out leaving them about half full ready for use.

Our manometers had graduations for different positions to give 2, 5, 10, 20, some of them 40 slant readings to one vertical and the zero angle on the circumference of the front plate and the reference line on the back plate. With the back plate set with its reference line opposite the zero line on the front plate when the tubes show level, any slant may be had by swinging to it.

The graduations need to be fine and accurately placed and at a good radius from the pivot, which should be well made so that there is no lost motion. These precautions are essential for good readings at the small angles 20:1 and 40:1.

The specific gravity of gasolene when filled to a hook gage mark in the neck of the can is usually determined by the weighing method. As two manometers are almost always used, it is convenient to check the specific gravity from time to time using water in one manometer and gasolene in the other and applying the same pressure to one leg of each, the height of water being divided by the height of gasolene. A can of gasolene if kept fairly well stopped does not change much in specific gravity, nor does that left in the manometer change fast. This point of density of gasolene must be watched, however, and the second method affords a convenient way.

In connection with gasolene manometers there is some apprehension in regard to gasolene vapor in the connections affecting the readings. The apprehension is found to be groundless when it is tried out. Even when the manometer is set to the smaller angles the tube and connections can be swung from several feet

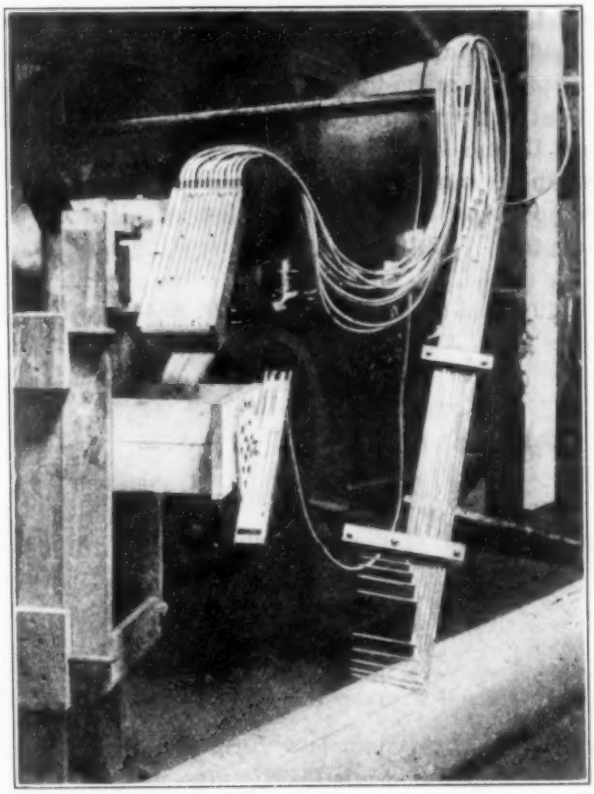

FIG. 14 PITOT TUBES READY FOR MEASURING ACROSS PIPE WITH INCLINING GASOLENE MANOMETERS

above to as many below without any noticeable change in the manometer reading.

In the use of manometers in this pitot tube work, whether water or gasolene be used, any change in the volume in the connections from evaporation of the liquid is freely vented through the tube orifices or at the open leg of manometer when both legs are not connected, and therefore no error can result from vapor pressure.

Fig. 14 shows an inclining manometer as described. The upper instrument is an inclining averaging manometer by means of which the mean reading of ten pitot tubes can be obtained. It is connected to give average velocity pressure across the pipe. The left leg of the manometer is connected to a static of one of the pitot tubes. The arrangement of static is usually correct, but when the amount in the pipe is disturbed the static is not uniform and constant across the measuring pipe, and static and total or impact must be taken separately. The discharge from a fan with outlet open cannot usually be measured in this way.

In Figs. 15 and 16 the areas and sections of the several tubes are all made the same. If AA is the level of the liquid when all tubes are open and if the liquid is depressed in the right-hand tube amounts a, b and c as the areas are the same the displaced liquid must rise in the left tube an amount a b c 0.
Add 0 to a and we have A, $b + 0 = B$, $c + 0 = C$

$$a+0 \quad + \quad b+0 \quad + \quad c+0 \quad = \quad 4 \quad 0$$

or

$$A \quad + \quad B \quad + \quad C \quad = \quad 4 \quad 0$$

and the mean reading

$$\frac{A+B+C}{3} = \frac{4\,0}{3}$$

For any number of manometer tubes n we have for the mean reading

$$\frac{A+B+\text{etc.}}{n-1} = \frac{n}{n-1}\,0$$

In use the distance 0 requires to be taken and multiplied by $\frac{n}{1n-}$.

So far as known this is a new form of manometer. It is interesting to watch the slight fluctuations in some cases of pressure across a measuring pipe. Plate glass was used over grooves milled in a brass body for this instrument.

The inclining manometer is accurate for small heads if the tubes are parallel and straight. The accuracy was tried out by simultaneous measurement of the pressure in connecting tubing by such a manometer at a 40 to 1 slant, by a hook gage on a good manometer and by a gasometer arrangement suspended inside a chemical balance. The measures checked very closely or to about 0.001 in. of water.

Mr. de Laval confers a favor by calling attention to the matter of determining the density of air under measurement giving a

formula for density. The tables published by the Navy Bureau of Construction and Repair show the weight of air for different temperatures, barometer readings and humidity up to 100 deg. and are a time saver within their range. Formula [15] applies to any gas by using the density of the gas measured. (See also Pars. 44 and 45.)

As to measuring the velocity of air flow in a pipe with the pitot tube at the center, the correction for average velocity should usually be determined by trial and especially if the pipe is short or if flow is in any way irregular. If gates are used on the measuring pipe it is necessary or the error may be considerable.

As to the velocities of air affecting the correctness of the pitot tube readings my evidence is that these readings are correct at

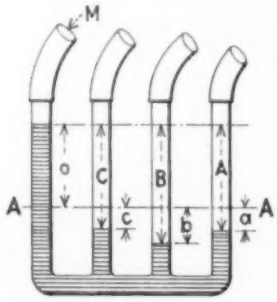

FIG. 15

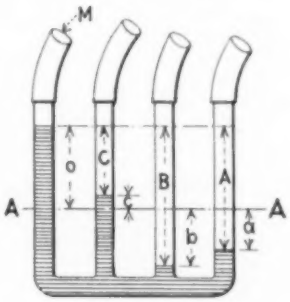

FIG. 16

EQUAL AREAS AND SECTIONS IN PITOT TUBES FOR USE WITH INCLINING MANOMETER

least to the limits stated and up to the speeds experimented with. That is, both static and impact orifices if they are as in Fig. 1 give true static and true impact pressures. The method of calibration is simple and direct especially for static orifice.

Possibly Mr. de Laval's experience has been with some of the forms having a faulty static orifice with which calibration was required to determine a constant in the relation $v = \sqrt{2gh}$. The form shown in Fig. 1 is simple and easy to make, the tip consisting of a ⅛-in. tube inside a ¼-in. diameter tube with walls about $^1/_{32}$ in. thick. Both static and impact are correct if made as shown. Accurate pressure measuring instruments are available and must be used and the ordinary precautions taken against leaks, etc., as noted through the paper and in Pars. 18 to 25.

THE VAUCLAIN DRILL

By A. C. Vauclain and H. V. Wille, Published in The Journal for October 1912

ABSTRACT OF PAPER

In the usual type of drill there are four distinct cutting edges. The actual cutting, however, is done mainly by the two edges extending from the outer circumference to points near the center. At the central portion of the drill are the two shorter cutting edges constituting the "chisel point" which do not cut freely and introduce stresses tending to split the drill.

The paper describes a new type of twist drill which has two radial cutting edges and in which the usual chisel point of such drills is eliminated.

In this drill the stresses due to the chisel point are absent and the arrangement of the cutting edges is such that a greater thickness of metal is secured at the center of the drill, adapting it to heavy feeds by which means the most economical results are secured in drilling.

Tables are given showing the results of comparative tests with the Vauclain and regular types of drills, indicating a saving with the former of over half the horsepower expended with the latter type.

DISCUSSION

J. Sellers Bancroft asked if any efforts have been made to ascertain the accuracy of diameter of holes drilled with the Vauclain drill. He thought it would be difficult to get the point of the drill exactly central, and in the production of holes of accurate size it is necessary for the reamer, which follows the drill, to have a definite amount to take off throughout. This amount should be neither more nor less.

H. P. Fairfield. The report of the horsepower expended as given in Table 3 shows a remarkable difference between the regular and the Vauclain drills. It would seem as if such differ-

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Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

ences in results could not be due to the design of the drills themselves, but must be the result of the method of testing. It would be interesting, therefore, to know how these tests were made and the apparatus used to measure the efficiency of the several drills. The reader could then analyze the tests and judge for himself as to their reliability and exactness. In much of the ordinary drill testing, the weaknesses and friction losses of the drilling machines are registered and charged to the drills being tested, which is obviously unfair. Several years ago at the Worcester Polytechnic Institute a drill testing dynamometer was developed which obviates such errors, registering only what is taking place at the drill point and entirely eliminating the drilling machine from the readings taken. If anyone compares his dynamometer results with the power input of this machine he will be shown conclusively that tests based upon the differences in power input are extremely unreliable. It is for this reason that the writer believes the method of conducting the tests should have been included. In a series of dynamometer tests upon a regular and a Vauclain drill made since reading the paper, the results showed no material differences in horsepower expended, and the writer cannot see why there should be such differences as shown in Table 3. As furnished him, the Vauclain drill is essentially a point thinned drill. Therefore the pressure at the point is reduced and the distortion in the machine lessened. However, if the regular drill is point thinned as is often done, the results in thrust are essentially the same.

The Vauclain drill appears to lend itself more readily to the point thinning principle than does the regular drill, and if extended use and tests should prove this to be so, it is obvious that an advance in drill construction has been made.

E. C. Peck. This paper points out a great many weaknesses of the well-known twist drill and has attempted to prove the superiority of a new type, but the author has described neither the apparatus nor the exact conditions under which the tests were made, in a way such that the student may judge to what particular detail the difference in results is traceable.

In Par. 1 he says the best definition of economical drilling is rapid drilling; this is not necessarily true. The writer has drilled cast iron 4 in. thick with a 1½-in. drill at the rate of 64 in. per min., probably the record at this date for rapid drill-

ing, but it was not economical because it consumed too much power and the drill was too near breaking all the time. A better definition of economical drilling is " the greatest amount of drilling that can be done per $1, counting the cost of time, power, machinery and drills."

In Par. 8 he says " The speed remaining constant—the power consumed by the *machine* remains constant for all feeds." It would be interesting to know how he determined this, as the coarser the feed the heavier the pressure on the drill to make it penetrate, and this puts more pressure per square inch on thrust bearings and feed parts which in turn increases friction.

Referring to Fig. 1, the cutting edges *A* and *B* being ahead of the center presents an advantage that the author has not mentioned, viz., they make a shearing cut with a tendency to carry the curling chips away from the axis of the drill.

The author lays stress on the splitting of drills and demonstrates the reason for this failure, but the splitting of drills is not a serious matter and a split drill usually shows a defect in the material or improper grinding, a fact which any large user of drills can easily verify by careful observation. The writer is in a position to observe the performance of several thousand drills each month which are tested to destruction under severe conditions and not one in 10,000 fail by splitting. If the chisel point spoken of has an inclination to the cutting edges *A* and *B* as shown in Fig. 1, there will be enough clearance at the center and the chisel point will cut easily enough to avoid splitting.

A great defect in the author's proposed drill, as shown by the writer's experience, is its inability to penetrate hard material. This is apparently due to the extremely thin center not being able to withstand the heavy feed pressure necessary to penetrate hard material. A more serious defect is the actual pressure of the chip against the surface *O* in Fig. 7. It does not curl freely as in the drill shown in Fig. 1 because there is no room; it must slide against the shoulder *O* Fig. 7.

In the regular type drill the cutting edge is extended past the axis an amount which allows free curl to the chips. If the regular and proposed drill used in the author's tests were properly thinned to the same thickness, there should be less power consumed by the regular drill because it bends the chips better.

Tests with Vauclain and regular drills made from the same

bar of steel and heat treated alike showed in every case that to withstand heavy feeds (0.100 in.) the temper of the Vauclain drill had to be lowered 20 to 30 points below the regular drills to keep the centers from breaking and they were then too soft for high speeds.

The tables do not show the "rapid drilling" which might be expected from the author's statements. The highest rate given is 15 in. per min. and double this amount can be done with regular drills. It would therefore seem that more extensive tests will be needed to make the superiority of the Vauclain drill apparent.

THE AUTHOR. In reply to Mr. Bancroft's question, accurate grinding of any drill is essential to the production of holes of accurate size. There is no difficulty in obtaining correct grinding in the Vauclain drill. No drill should be hand ground, and proper grinding machinery has been designed and built for grinding the Vauclain drill correctly. It is interesting, however, to note in this connection that much of the grinding of the Vauclain drills during the development was done by hand until the time when proper grinding machinery was available.

Replying to Mr. Fairfield, the author wishes to state that the remarkable difference in horsepower expended was not due to the method of testing but to the comparison between high speeds and heavy feeds. In other words, with a given rapidity of drilling a high-speed drill is made to depend upon high speeds and moderate feeds. The Vauclain drill utilizes heavy feeds and moderate speeds, the speed being kept just high enough to maintain within the drill a sufficiently high temperature to operate most successfully.

The author is not aware of any Vauclain drills having been furnished the Worcester Polytechnic Institute for the purpose of tests, and is of the opinion that perhaps such tests may have been made without a proper understanding of the intent of the drill design.

In reply to Mr. Peck, the apparatus and conditions under which the tests of the Vauclain drill were made were as follows:

The drilling machine used was a 60-in. radial drill press, one of a number built by Wm. Sellers & Co., Inc., of Philadelphia, and driven by a 20-h.p. variable speed direct-current motor. Current was supplied by an independent generator so that the

machine was entirely segregated from shop lines, the object being to maintain as constant a voltage as possible. A Westinghouse recording wattmeter, also an ammeter and volt meter for direct readings were located about 75 ft. from the machine so that readings could be taken without encountering the dangers of flying parts of broken drills. In this same location there was installed a cut-out switch so that the machine could be stopped at any time without approaching it. A steel guard was placed about the drill spindle as a further protection against flying pieces of broken drills.

The material drilled was tough, hammered steel of approximately 0.45 carbon. Heavy slabs of this material were used so that holes would have to be drilled through a considerable depth in all cases.

The author in stating that the best definition of economical drilling is rapid drilling believes he is correct and that Mr. Peck has misunderstood the statement. The most costly element in drilling is that of time; and, by the saving of time, assuming a rational design of drill and of horsepower consumption, the amount of drilling that can be done per unit of cost will increase as the time consumed decreases.

In Par. 8, referring to the statement, "the speed remaining constant, the power consumed by the machine remains constant for all feeds," the author should perhaps have explained this matter more in detail. It is true, as Mr. Peck has stated, that the coarser the feed the heavier the pressure on the drill to make the cut, and this puts more pressure on the thrust bearings and feed parts, which in turn increases friction. Attention is called to the fact, however, that the friction due to end thrust of the drill is so small as compared with the total power consumed by the friction of the machine that it may be considered negligible so far as power consumption is concerned. That the power consumption varies directly as the speed is but a mechanical law which may be verified at any time and by anyone by electrical readings. To elaborate this further, assume that with a certain size drill and a given rate of feed and speed there is a gross consumption of 6 h.p., and that half of this power is consumed by the machine, leaving a net cutting horsepower consumed of 3. Next assume an approximate doubling of the rapidity of drilling. If this is obtained by doubling the speed, there will be a gross consumption of approximately 12 h.p. If, however, the

rapidity of drilling is approximately doubled by increasing the feed and permitting the speed to remain unchanged, the gross consumption will be approximately somewhat less than 9 h.p. In a twist drill of the ordinary design, the difficulty of penetration and consequently the end thrust of the drill is aggravated by the chisel point. In the Vauclain drill, there being no chisel point, the end thrust upon the drill is very much less, consequently heavier feeds can be used in the Vauclain drill with less distress to the feed mechanism than would occur with the use of the ordinary type of twist drill.

The author cannot agree with Mr. Peck's statement that the splitting of drills is not a serious matter, and that the drill usually shows a defect in the drill material or improper grinding. The author has had a very large and intimate acquaintance with drills of all kinds. The central weakness of a milled drill is well known to all drill users. In the break-down tests made for the purpose of comparing the Vauclain drill with the ordinary design of drill, the ordinary designs of drill almost invariably split longitudinally, while the Vauclain drills, standing up under very much heavier duty as shown by the test data in the paper, fractured only when the torsional capacity of the section had been reached. Some of the drill manufacturers today, appreciating the seriousness of the central longitudinal weakness of the ordinary drill, have thickened their drills in the center, but this has increased the chisel point, consequently the difficulty of penetration. In the Vauclain drill there is no chisel point, consequently it may be made sufficiently thick in the center to enable the full torsional value of the drill section to be realized.

The author must disagree with Mr. Peck's statement in reference to the inability of the drill to penetrate hard metal. The Vauclain drill is especially adapted to the penetration of hard metal. It has no "extremely thin center." The so-called point on the Vauclain drill is merely the absence of a chisel point and is the strongest and most lasting and perfect part of the drill. It will not burn and it will not break under duties which would destroy the drill in every other respect.

With regard to the chip not curling, this is also incorrect. Since the cutting edges pass through the axis of motion, the chip at its inner edge has a length of zero while the maximum length of the chip is at the outer edge, consequently the outer edge of the chip is in rapid upward motion while the inner edge

is approximately at rest. These circumstances, combined with the flute of the drill, give the chip the proper curl. No difficulty has been experienced with the Vauclain drill in this respect.

As to the temper of the drills having to be lower than that of the regular drills, this is not at all necessary, as stated by Mr. Peck, to prevent the centers from breaking. The author has stated that the Vauclain drill is a heavy-feed drill and has pointed out and substantiated the fact that high-speed drilling is less economical than heavy-feed drilling, also that high-speed drilling is the result not of desire or advisability, but rather of inability to obtain, in the ordinary type of drill, any great amount of physical strength. In the Vauclain drill a tough rather than a hard drill is required, and it is intended that these drills shall be drawn at a lower temperature than the high-speed drill of ordinary type.

With reference to the drilling of 15 in. per minute, it is to be understood that this was done in a piece of 0.45 carbon hammered steel, approximately 4 in. thick and that the drill was permitted to emerge from the bottom of the work under full feed without the slightest injury to the drill. In the author's opinion, the drilling of 64 in. per minute with 1½ in. drill in cast iron is not to be compared in severity with the test just referred to. The greatest evil of end thrust on an ordinary drill is that under heavy duty it is apt to break when emerging from the work. With the Vauclain drill feeds of ⅛ in. per revolution have been successfully carried with 1 9/64-in. drill at high speeds.

TESTS OF A 1000-H.P. 24-TUBES HIGH B. & W. BOILER

By B. N. Bump, Published in The Journal for October 1912

ABSTRACT OF PAPER

The tests described in this paper were made on an inclined header Babcock and Wilcox boiler, with superheater and mechanical stoker. The experimental unit was installed for the purpose of determining the maximum heat efficiency and fuel economy, and the variation of such efficiency with changes in the boiler rating, also to gather data useful in the design of a unit for a large installation. The peculiar feature of the boiler is the unusual height; the sections being 24 tubes high.

A Foster superheater was placed between the top row of tubes and the boiler drums, and the gases entered the superheater after passing over 24 tubes. The superheat was found to go up with the boiler rating, increasing from 30 deg. to about 75 deg. fahr. for a change in rating from 55 to 120 per cent.

The fuel was burned on a six retort Taylor stoker having a grate area, exclusive of dump grate, of 62.5 sq. ft. One of the results of increasing the height of a boiler is a large ratio of boiler heating surface to grate area, which in this case was 160 to 1. Such a large ratio limits the capacity of the boiler, making it impossible to run at high boiler ratings.

The best combined efficiency, 81.3 per cent, was obtained at about 56 per cent of rating. The efficiency decreases slowly with an increase in the boiler rating. The low rating tests show exit gas temperatures but little above the temperature of the saturated steam in the boiler. The radiation losses are low considering the exposed condition and the low atmospheric temperatures surrounding the unit.

DISCUSSION

W. D. Ennis. The results of these tests do not apparently harmonize with principles usually accepted. It is customary to think of a 3 or 3½ lb. rate of evaporation as that of maximum efficiency. At rates below this, the efficiency is reduced by the increased proportion of radiation loss, and by the lower furnace

Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

efficiency, resulting from the low rate of combustion and necessarily excessive air supply. At evaporation rates higher than 3 or 3½ lb., efficiency is gradually reduced because of increased loss to the stack, as indicated by rising flue gas temperatures.

In this boiler, the efficiency steadily decreased as the rating increased, and the best efficiency was reached at an evaporation rate below 2 lb. When efficiencies are said to decrease at low rates the usual proportions of design are assumed: say with soft coal, a heating surface to grate surface ratio around 50. A 3 lb. evaporation rate means with this ratio, a rate of combustion of about 15 lb. per sq. ft. of grate per hour. No rate of combustion as low as this was reached in the present tests. In this boiler, with its unusual ratio of heating to grate surface, low rates of evaporation were not accompanied by low rates of combustion. At no time was the furnace efficiency notably lowered from the good average maintained.

It may seem that this scarcely explains the rate at which the efficiency apparently decreases with increased evaporation. As large a heating surface as was provided should have more completely absorbed the furnace heat. If Fig. 1-a is a scale drawing, a slightly better distribution of gas velocities would have been possible. It is quite easy, however, to over-emphasize the rate of decrease of efficiency, particularly as the *rating-combined efficiency* and *combined efficiency-gas temperature* curves of Fig. 2 are both represented to a distorted scale. The base line is that of 70 per cent efficiency, not of zero efficiency. The man on the street would say that the efficiency was about constant. In fact the curve of coal consumption against percentage of rating, Fig. 2, can scarcely be distinguished from a straight line. The flue gas temperature was 360 deg. at 56 per cent of rating and 400 deg. at 96 per cent: both figures are unusually good, with not much difference between them, certainly not more than would have been offset by the probably excessive air supply at the lower temperature and rating had the boiler had a grate of normal size. The difference between the efficiencies at half load and full load was about 1½ per cent. This means an excess coal consumption at full load of about 0.05 lb. per h.p-hr. Under the most unfavorable conditions, continuous service, the boiler running at full load would waste about $^1/_5$ ton of coal per year per horsepower capacity. To offset this waste it would be necessary to duplicate boiler, piping, smoke flue, etc., at an initial cost of per-

haps $20 per h.p. The saving of 1/5 ton of coal per year, which is the maximum possible, would usually not pay fixed charges on an investment of $20.

WILLIAM KENT. Fig. 2 confirms what has been generally found, that there is a slight decrease in efficiency with increased rate of driving of the boiler, and that decrease will be less the more the theoretical ratio of air approaches the combustible. If air supply is excessive the efficiency will fall off much more rapidly than is shown in Fig. 2. The reason why the maximum efficiency is shown at such a low rate of driving is undoubtedly due to the fact that this boiler was thoroughly covered with non-conducting material and the loss by radiation was extremely slight.

Professor Ennis has spoken of the rate of combustion and the ratio of heating to grate surface. Probably 15 years ago, at a meeting of this Society, in discussing a paper by W. W. Christie, the writer showed that there was no change in efficiency necessarily due to a change in the rate of combustion, between 5 lb. and 240 lb. per sq. ft. of grate surface per hour, except the loss due to sparks and cinders blown into the stack at the higher rate of driving. There is no necessary relation either between the rate of combustion and the excess air supply over that theoretically required; that is, with a rate of combustion as low as 5 lb. per sq. ft. of grate surface per hour, perfect combustion is possible with a certain small excess air supply, and at 20 times this rate without any greater percentage of excess air. The two variables are the thickness of fire and the amount of draft, both of which are under control of the fireman, and excellent results are also attainable with a high rate of combustion, provided the grate surface is small enough, and the draft and thickness of fire regulated to get the proper analysis of the gases. If there is about 3 per cent of oxygen in the waste gases, and in the case of a coal-burning furnace, an even fire, there will not be more than one-half of 1 per cent of CO, and that condition will give the maximum boiler efficiency, provided the baffles are properly arranged and there are no leaks of air or other troubles, and the boiler is not being driven beyond its most economical rate.

J. H. BROWNE said that the method of baffling this boiler was somewhat new. He had seen trials with a similar method of

baffling, but the experiments were not continued long enough to be conclusive. It seemed to him that although the method of developing a baffling material was interesting, the creeping of the tubes would break up the material, and he asked if the author had data on this.

The interesting fact was shown that the best economy was at from 50 to 60 per cent of the boiler rating, possibly accounted for by the superior installation of the boiler. In view of the fact that the ratio of 56 per cent appeared to be the best, this large boiler had at least one advantage from a commercial standpoint. Anyone who had to do with boiler-room operation no doubt knew that the average fireman liked to run about twice as many boilers as necessary. With a plant designed so that it would run at best efficiency at 56 per cent, this matter had been helped. On the other hand, a good deal more money was invested for the same size boiler under these conditions.

D. S. JACOBUS. Mr. Kent has said that the percentage of oxygen in the flue gases might to advantage be made lower than is indicated by the tests. An important feature of the analyses is that they nearly all show some carbon monoxides. The determination of carbon monoxide in boiler tests is often subject to considerable error. In the present instance the analyses were undoubtedly correct, and the limitations in efficiency through striving to run with but little excess air, or a low percentage of oxygen in the flue gases, is clearly brought out.

On decreasing the amount of excess air there is a tendency to approach a zone where carbon monoxide will appear in the flue gases. The better the furnace the higher the percentage of carbon dioxide will be before the carbon monoxide appears. In endeavoring to obtain high efficiencies, we take great care to watch for carbon monoxide. It is often an easy matter to get, say, 10 or 11 per cent of carbon dioxide with little or no carbon monoxide, but after exceeding 13 per cent of carbon dioxide the furnace must be exceptionally good to consume all of the carbon monoxide.

Measuring the furnace temperatures has been suggested. It is extremely difficult, if not impossible, to do with accuracy, as the effect of the radiant heat complicates matters. A long time ago I calibrated a Uehling-Steinbart pyrometer, and great difficulty was experienced in obtaining comparative temperatures.

In an ordinary furnace the temperature of the gases may be different from the temperature due to the radiant heat and on this account there are variations depending on the form of the end of the pyrometer which is exposed to the conducted and the radiant heat. The arrangement of the water heating surface with respect to the furnace also affects the temperature measurements, and the same applies in a lesser degree to temperature determinations of the gases at different points within the setting.

C. D. Young. In some recent work with superheater locomotives we have found that generally the superheat will increase with increased evaporation or increased burning rate of the boiler. This is confirmed in stationary practice, I see, by the conclusions drawn in Par. 21. The diagram which illustrated this, however, has the line curved in the upper right hand corner, whereas our tests with a superheater applied to water tube locomotive boiler seem to indicate that the line should be straight; that is, the increase in superheat is almost directly proportional to the increase in the burning rate.

A question which we have before us just now in locomotive practice is the determination of the effectiveness of water and superheating heating surface in a boiler and I would like to know if Mr. Bump has data to show what the heat transference rates are as between the flue gases and the water and the flue gases and the steam. Our results seem to indicate that the superheater heating surface *per se* is only about half as effective as the water heating surface in heat transfer.

The Author. Professor Ennis has made the statement that "as large a heating surface as was provided should have more completely absorbed the furnace heat." I would call his attention to the last two columns of Table 3 which show that there was very little difference between the temperatures of the gases leaving the boiler and the saturated steam in the boiler. The temperature of the fluid within the tubes is the minimum limit of the exit gas temperature, and no amount of heating surface will reduce this limit.

The difference between the efficiencies at half load and full load was more than 3 per cent, not about 1½ per cent as Professor Ennis has stated. This means that the boiler running at

full load would waste 0.5 tons of coal per horsepower-year, instead of the 1/5 ton stated in the discussion.

Although there is fuel economy in running at half load, yet fuel economy is not all there is to the cost of steam.

These tests are not put forward to show that the cheapest steam is to be obtained at low boiler rating. This would only be true with a very high priced fuel. With the usual prices of coal, and interest and depreciation taken into account, this boiler would need to run at 150 per cent rating at least, in order to generate steam at the lowest cost.

In reply to Mr. Young relative to the superheat curve of Fig. 2, the points obtained by these tests as well as from a later series of tests made after the baffles had been removed indicate that the line should be a curve, not a straight line. In other words, the superheat did not increase so fast as the boiler rating. The fact that the superheater was too small for the quantity of steam generated at the highest ratings may have had some influence upon the superheat.

In regard to the relative rates of heat transfer in the superheater and in the boiler, we have no data that will give an absolute measure of this transfer, but can get an approximate comparison from the drop in temperature of the gases as they pass over the several surfaces. Making calculations on this basis, we find that the rate of heat transfer for the superheater is fully as great as for the adjacent portions of the boiler tubing.

AXIOMS CONCERNING MANUFACTURING COSTS

By Henry R. Towne, Published in The Journal for December 1912

BRIEF

In a paper entitled The Enginner as an Economist, contained in Volume 7 of the Transactions, 1886, by the present writer, is the following statement:

"To insure the best results, the organization of productive labor must be directed and controlled by persons having not only good executive ability, and possessing the practical familiarity of a mechanic or engineer with the goods produced and the processes employed, but having also, and equally, a practical knowledge of how to observe, record, analyze and compare essential facts in relation to wages, supplies, expense accounts, and all else that enters into or affects the economy of production and the cost of the product."

The following paper attempts to sum up the results of modern experience in these matters, and to state the views now generally held concerning the fundamental principles which underlie industrial accounting. The conclusions reached are embodied in the Axioms; the arguments on which the latter are based are contained in the intermediate text.

DISCUSSION

Arthur C. Jackson. I wish to point out a different procedure from the one suggested by the author in Axiom 9. If the interpretation of the author's statements and the arguments I wish to present for consideration can be accepted, a somewhat different result than that which has in the past been generally acknowledged correct will have to be considered.

If in Par. 12, " production and selling are two separate and distinct processes " (and I would be willing to differentiate still more decidedly between them and call them separate and distinct functions), is there any reason for distributing commercial expense upon the bases of shop costs?

The statement in Par. 11 advocating the elimination of material

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from the basis of distribution of non-productive or manufacturing expense on account of its varying value should lead to the elimination of this variable component from the basis of distribution of commercial or selling expenses. This leaves only two bases upon which commercial or selling expenses may be distributed, productive labor or selling prices.

Inasmuch as "producing and selling are two separate and distinct processes," does it not appear that the total selling expense should be distributed upon the basis of sales, just as the total of all expenditures incident to, and not an element of, the production or the product, are distributed upon the basis of productive labor?

Is it not often the case that the selling price of the manufactured product remains more uniform than the prices of the materials entering into its manufacture; and that the selling price is much more affected by market and trade conditions than by variations in factory costs?

It is always the ideal of the efficient works manager to get out an ever increasing production with an improvement in quality and a reduction in costs. Likewise it is the object of every sales manager constantly to increase the volume of sales, increase the profit and reduce the proportionate selling expense.

Is not, therefore, the total value of sales the proper basis for the distribution for commercial or selling expenses? This is where the principle that an article can have but one cost fails and so may my argument, but I submit it for consideration because I believe it to be convenient, especially where we have to compete in export markets with foreign competition at a lower price.

If my mthod of determining cost by basing commercial or selling expense upon the sales instead of upon the manufacturing cost could be accepted and used it might result in less oppression of the American manufacturer by the departments of justice and internal revenue and tariff boards, as we could then *show* that goods sold in export markets at a price below the domestic actually have a lower cost than goods sold in the domestic markets at a higher price.

Augustus Smith. The title of Mr. Towne's paper, Axioms Concerning Manufacturing Costs, does not at once suggest the full scope of the paper. We want to know the final or "actual cost," as Mr. Towne puts it, to know what to charge for our

product as well as to analyze and study all the various elements that go to build up the cost in order to improve and make more efficient the other departments of a business after the manufacturing department has done its best.

In addition to all this, we want to know what is our actual profit in order to pay proper dividends or to settle equitably all claims based on the cost or on a share of the profits. By a provision of the Payne-Aldrich bill passed August 5, 1909, manufacturing corporations are required to report to the Internal Revenue Bureau what their annual net profits are, and are required to pay a tax on any such profits that are in excess of $5000 per annum.

Thirty-four or more states have passed legislation authorizing a federal income tax. The difference between apparent, estimated or scientifically determined profits will soon make a difference in the taxes we have to pay as individuals.

The writer hopes that the society will take steps to have the subject treated by Mr. Towne investigated by a committee under his guidance with a view to reporting upon a method for computing costs that will be generally accepted as standard

a For paying dividends
b For settling claims based on a share of the profits
c For paying for or receiving payment for work done on "cost" plus a percentage or "cost" plus a fixed sum
d For paying income taxes.

There is no standard practice now. There is no room for bitter disputes on any of the above calculations.

On the back of the blank which the writer's corporation filled out for the Internal Revenue Bureau are printed instructions as to how income shall be determined. This is an extract:

16. The gross income of mercantile corporations should be ascertained in the following manner: From the sum of the total sales during the year plus the amount of the inventory at the end of the year deduct the sum of the inventory at the beginning of the year plus the cost of goods and materials purchased during the year. To this difference add the income received from any other source, and the result will be the gross income to be reported under item No. 3 of the return.

17. The gross income of manufacturing corporations should be ascertained as in No. 16 except that the cost of manufacture should be included in the deduction to be made from the sum of the sales made during the year and the inventory at the end of the year.

It is only necessary to point out that in many businesses the execution of orders taken or sales made in one year may extend far into the next year or the year thereafter to show that the method of accounting suggested by the government does not in all cases show the correct income of a corporation in the sense probably intended by the act.

The method which Mr. Towne has suggested of keeping separate account of the surplus has a direct bearing on this question. For instance, a firm's receipts in one year might far exceed the disbursements, due perhaps to deferred payments coming in or to the cumulative or fortunate result of advertising or of previous soliciting or what not, and without an accepted system of surplus accounting, such a firm might be mulcted for a heavy tax to the government or might have to pay out large sums to parties interested in a "share of the profits," notwithstanding the fact perhaps that for several years previously the firm had been apparently steadily losing money and might expect deficits again for the next few years.

The cycle of planting, cultivating and harvesting in a manufacturing business is not necessarily coincident with the calendar year, and the status of such a business cannot be shown properly at fixed yearly periods without a surplus and shortage account. If a business had to borrow money for several years before revenue began to come back, any funds so borrowed should be repaid before any profit could be declared. Just so with the surplus and shortage account.

The writer does not quite follow Mr. Towne in the matter of interest. Interest on borrowed capital which the author classes as part of the profits seems to the writer to be more conservatively considered as an expense and part of the cost. A sharp distinction can be drawn between interest and other forms of profit. Interest on borrowed capital has to be paid whether or not there is any profit in the business. The stockholders may levy an assessment or borrow more money to pay it, but pay it they must or turn over the business to a receiver.

The author cites two profitable businesses, one where *A* puts in $200,000 as capital while in the other *B* puts in $100,000 as capital and borrows $100,000 at 5 per cent. Each makes $20,000 which is 10 per cent on *A's* capital while *B* divides his $20,000 of profit into 15 per cent on his capital and 5 per cent interest on his borrowed money. But suppose each business lost $20,000.

This would be 10 per cent loss on *A's* capital, but *B* would have to pay 5 per cent on his borrowed money just the same and face a loss of $25,000 on his capital or 25 per cent. The fact of the matter is the borrowed capital is not "on the table" in the sense of being exposed to the hazard of the business.

Another way of looking at borrowed money is that many businesses, especially those which the author characterizes as engaged in contract work, have no definite amount of invested capital, in his conception of the term. Such firms take as much business as they can get hold of and then raise the necessary additional capital to handle the business just as they take on extra hands to execute it, and the interest they pay for this capital must be considered an expense the same as are the wages they pay for the extra men and to be deducted before any profit is declared. The writer thinks therefore that Axiom 15 should be amended to read *Interest on Borrowed Capital should be treated as an Operating Expense.*

The object of this discussion, however, is to emphasize the vital importance of Mr. Towne's paper calling as it does for agreement in the method of accounting or the creation of a correct science of industrial accounting. The writer's appreciation of the value of the paper is such that he has hesitated to express a divergent opinion concerning Axiom 15. The main thing is to work for a standard system which can be amended from time to time afterward if necessary. As the author says no standard as to what such words as "earnings" and "profits" mean has as yet been established. Scientific management without scientific accounting is like professional billiardists competing without keeping the score.

WM. KENT. Referring to Mr. Towne's percentage distribution of the several items of cost given in his table in Par. 7, he takes the total cost, including the commercial expenses at 100 per cent and expresses the several items as percentages of that total cost. In my experience as an accountant I have found it preferable to take the factory cost of the goods packed and in the warehouse at 100 per cent, and to express the several items as percentages of that total. By this method the table would be modified as follows:

Nos.	1	2	3	4
L = productive labor	31	24	35	24
M = productive material	42	47	30	48
PC = *prime cost*	73	71	65	72
Me = manufacturing expenses	27	29	35	28
SC = *shop cost*	100	100	100	100
Ce = commercial expenses	11	43	22	28
AC = *actual cost*	111	143	122	128
Total expenses (that is, $Me+Ce$) =	38	72	57	56

The factory cost is the labor, plus the material, plus the factory expense. The factory should make the goods as cheaply as it can and sell them to the selling department either at an agreed price or at some percentage of the factory cost. In a factory in which I was interested we arbitrarily fixed the price to the sales department at 50 per cent of list (we had a list price from which discounts were usually given), and we said that the factory should make the goods for half the list including the factory expense, and the factory should make a profit on them at that price if it could. The selling department should buy the goods from the factory at 50 per cent from the list and sell them for what it could, and make as much profit as it could. The accounts of the two departments, the factory and the selling department, should be kept separate.

THE AUTHOR. Mr. Jackson's comment on Par. 12 shows that he is in accord with me as to the distinction between production and selling. It seems immaterial whether we call these divisions processes or functions.

He contends that it is not often the case that the selling price of a manufactured product remains more uniform than the prices of the materials entering into its manufacture. Possibly this is true when the product is simple and staple; it is not true, however, as to specialized products, especially those controlled by patents or trademarks, the prices of which frequently remain unchanged for months or years, whereas the prices of the materials from which they are made usually fluctuate weekly or daily.

I do not regard "sales" as a proper basis for the distribution of commercial or selling expenses. In the case of staple products prices fluctuate frequently, sometimes daily, and in the case

of nearly all products different prices are charged for the same article at the same time to different classes of customers. The price basis, therefore, is a fluctuating one, whereas the cost basis is substantially constant, the changes in it taking place gradually and infrequently. I believe that on full consideration of all the factors it will be found that "shop cost" constitutes the most logical, most stable, and most accurate basis for the distribution of commercial expenses.

Mr. Smith suggests that the importance of the subject justifies the appointment by the Society of a special committee to formulate and submit a standard system for computing manufacturing costs. I heartily concur in this suggestion. Already, in several lines of industry with which I am familiar, there is a movement among the manufacturers concerned to bring about a uniformity in methods of cost acounting, in order thereby to promote closer uniformity in quotations. Experience has shown that divergence in quotations is frequently based upon divergence in costs, due in turn to divergence in methods of computing costs. The Society can render no greater service to organized industry than by taking the lead in bringing about a reform in the method of computing costs, and in establishing a standard method for the accomplishment of this vitally important part of the work of industrial management.

Mr. Smith questions the correctness of my views concerning the distribution of interest on capital. He says "interest on borrowed capital has to be paid whether or not there is any profit in the business." This may be true also as to dividends. A dividend is sometimes paid (out of accumulated profits) when it has not been earned, and still more frequently the dividend actually paid represents only a fraction of the profit earned. In both cases the question relates merely to the disposition of profits, and to the different ownership of capital involved. Mr. Smith would amend Axiom 15 to read "Interest on borrowed capital should be treated as an operating expense." To this I must dissent. It is immaterial who owns the capital employed in a business, and whether it is represented by stock, by bond, or by bills payable. All of it should be treated alike for accounting purposes. Either no deduction should be made from profits on account of interest on capital, or else interest should be deducted on the entire amount of capital employed. Any other division

would imply differences between the results obtained in one case and in others which would be fatal to the establishment of a standard of comparison.

I endorse unqualifiedly Mr. Smith's closing statement that the main thing is to work for a standard system.

DIMENSIONS OF BOILER CHIMNEYS FOR CRUDE OIL

AT SEA LEVEL AND AT VARIOUS ALTITUDES, WITH CORRECTING FACTORS FOR FUEL ECONOMIZERS

By C. R. Weymouth, Published in The Journal for October 1912

ABSTRACT OF PAPER

Chimney tables applicable to boiler plants using coal fuel give dimensions larger than necessary for oil fuel. It is impossible to compile a single table of correct chimney capacities applicable to different types of boilers, operating conditions, etc., for oil fuel.

This paper sets forth the elementary principles for the determination of the dimensions of chimneys, with special reference to the use of crude oil; it also presents data regarding the draft necessary for burning oil under Babcock and Wilcox boilers of various sizes, at various ratings, and a table of chimney capacities applicable to certain sizes of Babcock and Wilcox boilers.

The operating fuel economy of a crude oil plant is largely influenced by the excess air supply due to excessive draft, and the author recommends the use of lower chimneys than customary, particularly for uniform load plants, not subject to overload, as affording a means of chimney regulation of fuel economy.

Errors are shown in previously accepted formulae for variation of chimney proportions for operation at different altitudes, and correct formulae are given.

Data are given regarding the frictional resistance of fuel economizers, and a table presented showing ratio of reduction of chimney capacity, due to cooling of gases within economizer, and the resistance of economizer. Dimensions of steel chimneys are given for minimum first cost, and selection of type of chimney suitable for quick starting reserve plants is discussed.

DISCUSSION

William Kent. In regard to what Professor Jacobus had said as to oil burning, the writer had an opportunity to make

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a test with a Scotch marine boiler having four furnaces, each with one oil burner. The test was under forced draft with the furnace and ashpit doors closed so that the flame could not be seen; one of the burners got out of order and smoked badly for a long time before its condition was discovered.

It appeared that when more than one burner was in use, one of them might be running with too much air and another with too little, both giving poor economy, while the average flue gas analysis would indicate that the air supply was just right. The writer was looking for an apparatus resembling a steam gage, with a pointer to indicate the percentage of oxygen in the chimney gases, and asked if anyone knew of such. If the combustion chamber and flues beyond it were so divided that each section of the chamber were fed by one burner, the indicator would show whether or not each burner was working under ideal conditions. The condition of successful operation of either oil or coal-burning furnaces was, as far as he was able to find, that the oxygen in the gases should be between 3 and 5 per cent, hot air would uselessly be carried out of the chimney. The apparatus he wanted would tell him when he had between 3 and 5 per cent of oxygen in the gas.

E. H. Peabody referred to Mr. Kent's remarks that it is possible to have two burners in operation, one with too much air and one with too little. The furnace under consideration is designed to take care of a poor mixture, and it is quite possible to take care of any irregularities of that kind; but of course it is a mistake for one burner to get too much air as that can be regulated. The importance of furnace in oil burning is much greater than that of the burner.

D. S. Jacobus. Mr. Weymouth will naturally answer the questions that have been asked about his paper, but I might say that Mr. Kent's idea of determining the oxygen component in the flue gases in place of the carbon dioxide is a feature that is not as important as the accurate determination of the carbon monoxide. Mr. Kent says that 3 per cent of oxygen is a good amount in oil burning, but this is not all that must be strived for, as with 3 per cent of oxygen a poor furnace may allow considerable carbon monoxide to escape to the stack, whereas with a good fur-

nace there would be no carbon monoxide, or at best not over one-fifth of one per cent.

THE AUTHOR. Mr. Kent's discussion refers to the question of oil burning, rather than directly to chimney capacities, which is the subject matter of this paper. It appears that Mr. Kent has been fully answered by Dr. Jacobus and Mr. Peabody.

In view of the recommendations in this paper in favor of low chimneys for boilers operating at uniform load, it is advisable to repeat a well-known caution in regard to the effects of downward currents of the air during high winds when the chimney is unfavorably situated in respect to surrounding buildings, hills, etc.; with a low chimney the loss of draft from this cause is more pronounced than with higher chimneys. Based on the formula for pressures due to wind velocity given in Kent, the writer has computed the corresponding pressure in inches of water for various velocities as follows:

Wind Velocity, Miles per Hour	Equivalent Pressure, Inches of Water	Condition of Wind
1	0.0005	Hardly perceptible
2	0.002	Just perceptible
3	0.0044	
4	0.0078	Gentle pleasant wind
5	0.0122	
6	0.0176	
7	0.0176	
8	0.0239	Pleasant brisk gale
9	0.0395	
10	0.0489	
12	0.0705	
14	0.0955	
15	0.11	
16	0.125	
18	0.159	Very brisk
20	0.195	
25	0.306	
30	0.447	High wind
35	0.6	

These pressures are realized on a plain surface at right angles of the direction of the wind. The vertical component of wind velocity would be effective only in the case of boiler chimneys.

Since the preparation of this paper, data have been secured

on a rather interesting oil burning plant, the results of which appear to be quite ideal. The plant in question is the Sloat Boulevard Pumping Station of the Spring Valley Water Works, San Francisco. There are installed two Babcock & Wilcox boilers, each rated 152.5 h.p. There is also installed a Green fuel economizer having a total of 16 sections, each containing six tubes 4 in. in diameter. The whole is connected to chimney 66 in. in diameter, having a top height of 35 ft. above boiler room floor line.

The chimney has a relatively large diameter for the work and the draft loss by friction is therefore minimized. There is one right-angle turn from the boilers entering the economizer with a straight pass from the economizer to the chimney, except a right-angle turn in passing upward into the chimney.

The station records of water and oil measurement indicate that the boilers operate at about 10 per cent above rating, one boiler only being in service at a time.

In order to obtain sufficient air for combustion, it is necessary to keep wide open the front ashpit doors, rear boiler damper and stack damper. While no observations were made of the gas analysis, it appeared that combustion was proceeding with the usual minimum air supply and without smoke. If such is the case, it is apparent that when operating at this load, the most negligent fireman could not materially increase the air supply for combustion, because all air doors and dampers are wide open and there is no means of increasing the draft.

The author has suggested for trial purposes, the further reduction in stack height by the removal of one course of steel, but this has not as yet been tried. The writer knows of no better example than this for the regulation of boiler efficiency by stack height; such regulation, however, is limited to plants operating under practically uniform load conditions.

CASE CARBONIZING

By Marcus T. Lothrop, Published in The Journal for December 1912

ABSTRACT OF PAPER

The case-carbonizing process requires an increasing of the carbon content of the surface of the material treated while the original composition of the interior is retained. It is essential that the details of the operation be understood to secure uniformity of product, and these researches were undertaken with the object of determining the causes of irregularity and the precaution which must be employed to secure uniform results.

The experiments undertaken were to determine:

a The effect of heat treatment in case-carbonizing steels upon the physical properties of the metal.

b The effect of temperature used in case carbonizing.

c The effect of heat treatment after case carbonizing.

d The effect on the rate and depth of carbonization of the composition of the steel being case carbonized.

e The efficiency of case-carbonizing materials.

f The rapidity with which heat is conducted through carbonizing materials.

The conclusions deduced in each case are listed in the body of the paper under the headings corresponding to the several experiments, and the detailed results of the experiments are tabulated for further reference in the appendices.

DISCUSSION

Albert Sauveur.[1] Those interested in the case hardening of steel will be greatly indebted to Mr. Lothrop for his extensive investigation of the subject and for the simple manner in which his results and conclusions are recorded. These results on the whole agree closely with our present understanding of the case hardening operation. We have realized for some time that careful heat treatments were needed after carbonizing in order to

[1] Prof. of Metallurgy and Metallography, Harvard University, Boston, Mass.

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confer a fine structure both to the core and to the case. It was not so generally known, however, that the strength and toughness of the case-hardened article could be further increased by tempering. It is the writer's opinion that little is to be gained by tempering case-hardened articles for the following reasons:

"There seems to be at first sight no apparent reason why case hardened articles could not be likewise improved by suitable tempering following the hardening of the case. On second thought, however, it will be realized that since the chief purpose of tempering is to toughen the hardened steel and since hardened articles depend for their toughness on the toughness of their cores little is to be gained by tempering them."[1]

Referring to the exhaustive tests which the author conducted in order to ascertain the relative merits of various carbonizing materials, it is somewhat disappointing that he fails to give the names of the various substances investigated. The reasons for the author's secrecy in this matter are not readily understood. Referring to material No. 14, the writer infers from its composition that it consists of a mixture of charcoal and of barium carbonate and notes that the results obtained by its use are very satisfactory. This confirms his own experience with this kind of material.

J. A. MATHEWS[2] said he had watched the progress of the work described in this paper during the two or three years that it had been going on with a great deal of interest. He had had personally but little to do with the paper, which represented the work not only of Mr. Lothrop and his assistants on the steel making side, but also considerable work of the metallurgical staff of the H. H. Franklin Manufacturing Company and the Brown-Lipe-Chapin Company, both of which had done large amounts of case hardening. The paper was of extreme value, and virtually reduced case-carbonizing to a science. By following the directions and observing the results as given in the paper, it would be possible to do case hardening with an extreme degree of accuracy in duplicate parts. That was something that had not always been done. One of the most important points covered by the paper was in relation to the thermal conductivity of the different compounds. That was something that should be known regarding all the different compounds, particularly in the case

[1] The Metallography of Iron and Steel, Albert Sauveur, 1912, Lesson 16, p. 6.

[2] Genl. Mgr., Halcomb Steel Co., Syracuse, N. Y.

of changing from one to another where the mere change due to the difference of thermal conductivity of the material in the box would affect the total penetration of the carbon in a given time or at a given temperature. But if the relative conductivities were known such differences could be prevented. Such data had not been available in the past. Mr. Lothrop and his collaborators in this work were entitled to great praise for the thoroughness with which they had carried on this investigation.

ROBERT R. ABBOTT.[1] The meaning of the author in many places is obscure. For example, Appendix No. 1, test No. 1, treatment was given as quenching from the pot at 1500 deg. To make a legitimate comparison of this test with tests Nos. 2 to 12 it should have been carbonized in the same furnace and cooled under identical conditions with them. Were the pots removed from the furnace to cool? The carbonized temperature is given at 1700 deg. Then how was this No. 1 test quenched at 1500 deg.? How was this 1500 deg. measured? In the summary at the bottom of Appendix No. 1, Table 12, the best single treatment is given as quenched from 1600 deg. (test No. 4) and yet test No. 1 quenched from pot at 1500 deg. gives a higher rupture load (900 against 850) as well as a better deflection (0.40 in. against 0.24 in.).

In Appendix No. 1, Tables 13 to 21, under Summary 1 is stated "Strength and toughness decreases with increasing depth of case." This is an example of a common error into which many investigators are led. It is a conclusion based upon insufficient or faulty experimental data. The expert investigator eliminates all variables but one. In this case two variables were present, first, a variation in the depth of carburization and, second, a variation in the *correct* heat treatment, since the different depths of carbon undoubtedly had different percentages of carbon at the surface and the treatment should have been changed to suit the different conditions; instead of this the same temperature was used for all depths. For example, Table 13, Treatment 1: if 1500 deg. produces a certain condition in the case with a depth of 0.01 in., will 1500 deg. produce the same condition when the case is 0.02 in. The writer has not considered this point in drawing his conclusions.

Appendix No. 1, Table 16, Summary 4: The best double treatment is given as 1600 oil—1500 oil, while from the tables this is

[1] Metallurgical Engr., The Peerless Motor Car Co., Cleveland, O.

not as good as 1600 oil—1500 water. In general the writer questions many of the conclusions of the author as given in his summary. For example, comparing Table 16, treatment No. 14 with treatment No. 17, the use of 1500 deg. for the second quench has increased the load from 1240 to 1390, or 12 per cent, while the deflection is decreased from 0.75 in. to 0.44 in. of 41 per cent. There can be no question but that the author has not drawn correct conclusions; 1600 deg. oil—1300 deg. oil is by far the better. A shock test would show this. For the same reason the author's conclusions in Par. 7 *f* are incorrect.

In Table 19 the author's best double treatment, namely, 1500—1400 is in reality but a single treatment as the final quench (1400 deg.) is about 20 deg. above the upper critical temperature of the core and therefore both the core and case are in the solid martensitic condition, which is absolutely wrong from a theoretical as well as a practical standpoint.

Considering the author's conclusions regarding the best single and double treatment for different carbon nickel steels:

	Best Single	Best Double	
0.10 Carbon	1500	1600	1500
0.15 Carbon	1500	1600	1500
0.20 Carbon	1450	1600	1400
0.25 Carbon	1500	1550	1400
0.31 Carbon	1400	1500	1400

Why should there be such a drop and then a rise in the best single treatment at 0.20 and 0.25 carbon? Why should the best double treatment have no variation in the best treatment, for the 0.10 and 0.15 carbon and also for the 0.20, 0.25 and 0.31, but vary 100 deg. between the 0.15 and 0.20 carbon? This is manifestly not probable.

In general the value of the experimental data, given in Tables 12 to 21 inclusive, is questionable as this work represents a series of hit and miss treatments with no evidence of a fundamental knowledge of the theory upon which correct heat treatment is based. This is particularly evident in the so-called double treatments, many of which are in reality not a true double treatment, i. e., one in which first the core and then the case is affected.

Particular attention might be called to the fact that many of these treatments could have been improved if the oil and water quenching had not been indiscriminately used. An oil treatment does not affect the case as deep as a water treatment. In other

words, an oil treatment, if done at the right temperature, leaves the steel in a condition similar to a steel carbonized to a less depth, but water treated. Briefly then many of the author's results with oil treatment could have been duplicated by a water treatment with a shallower carbonization and therefore with a saving in cost.

The conclusions given in Par. 11, when taken in connection with the temperature given for the best single and double treatments, particularly of steel No. 7, have not been made with due regard for experimental evidence offered. They are incorrect.

Par. 33 *d* is too broad a statement, since the presence of needles of cementite is not caused entirely by high temperature as this can also be produced by a longer time of carbonization at a lower temperature.

The statements in Par. 33 *g* cannot be condemned too strongly in view of what is one of the most important and fundamental operations in the scientific heat treatment of carbonized steel. If the steel has been correctly treated subsequent to carbonization the excess cementite will not exist " in the form of film of carbide between the grains of the metal " as the author states. If the practical man was unable to take advantage of the better wearing surface produced by a carbonization of greater than 1.00 per cent surface carbon without the danger of " rendering it liable to fail by flaking off or spawling " he would certainly be behind the times in these days of rapid increase in the knowledge of heat treating. The above statement also applies to Par. 47 *e*.

The explanation in the second part of Par. 33 *h*, as has been so ably given by Dr. H. M. Howe, is taken by the author as a reason for the flaking off of the case from the core. While this tendency is undoubtedly present if the material is not subsequently given a correct heat treatment, many practical case hardeners can carbonize an open hearth steel at say 1750 deg. in the proper material and then by a correct heat treatment make it as efficient to resist flaking off as could be done by carbonizing at 1650 deg.

In the third part of this paragraph stress is laid upon the coarsening of the grain size by high heat. This is of little practical importance as correct heat treatment will break up any grain produced during the process of carbonization.

Uniform results cannot be obtained by the repeated use of carbonizing material for high-grade work as advocated in Pars. 47

and 48. Mixing part old and part new is not desirable as the old material generally is not uniform, having been used for different lengths of time and at different temperatures.

BENJ. E. BOSLER[1] presented in a written discussion some notes on case hardening. The parts were case hardened at No. 1 Smith shop. About 700 or 800 bevel and spur gears for mill roller runs have been treated during the past three years, varying in size

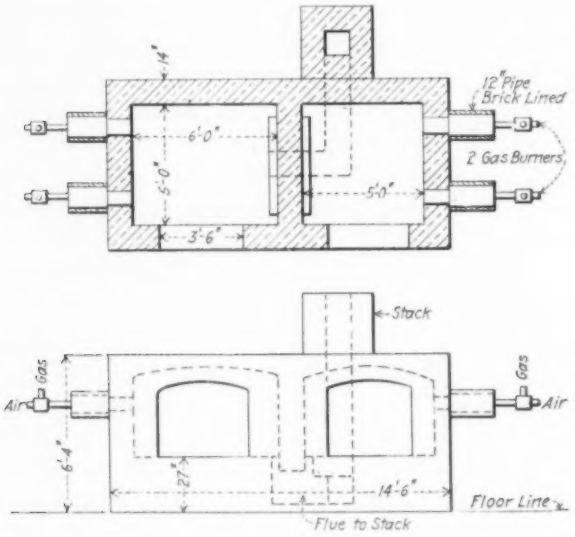

FIG. 31 FURNACE FOR CASE HARDENING. NO. 1 SMITH SHOP

from 10 in. to 18 in. pitch diameter and about 4 in. to 5 in. width of face. Practically all crane and motor pinions are now case hardened and a few spur gears as large as 30 in. in diameter by 8 in. face have been treated.

About 90 per cent of the case-hardened gears are made from open hearth steel forged blanks of dead soft stock with carbon between 0.8 and 0.12 per cent. The company has case-hardened steel with a carbon content as high as 0.20 per cent but finds that the best results are obtained by using steel with carbon under 0.12.

The other 10 per cent of the gears treated are steel castings made to the following specifications: carbon 0.10 to 0.15 per

[1] Asst. Supt. Mech. Dept. Cambria Steel Co., Johnstown, Pa.

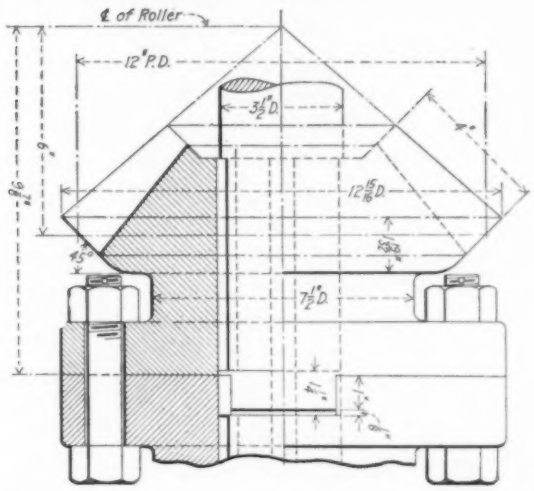

FIG. 32 HALF COUPLING WITH MITRE GEAR, NO. 1 MILL FURNACE RUN; 0.12 PER CENT, CARBON STEEL; CASE CARBONIZED ON FACE AND IN BORE AND KEYWAYS. PENETRATION, ¼ IN.

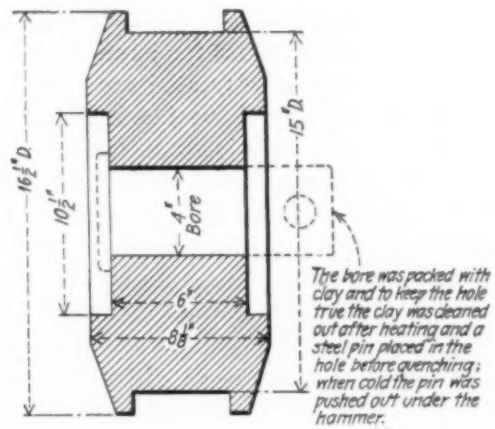
16½" D.
10½"
4" Bore
15" D.
6"
8⅛"
The bore was packed with clay and to keep the hole true the clay was cleaned out after heating and a steel pin placed in the hole before quenching; when cold the pin was pushed out under the hammer.

FIG. 33 CASE-HARDENED ROLLER FOR ORE SCREENING PLANT. ABOUT 30 HOURS IS REQUIRED FOR 3/16 IN. PENETRATION

cent; sulphur not over 0.05; phosphorus not over 0.04; silicon 0.15 to 0.30; manganese 0.60 to 0.80.

Regarding the life of the case-hardened gears, the roller run was installed in front of mill furnace No. 1 about four years ago where about 200 case-hardened gears were used and up to this time not one has been replaced, although the table has had very hard service. Gears in the roller runs leading up to the 18-in. mill, in the roller runs at Gautier 24-in. mill and in the tables at the Franklin mills, are giving equally good service.

Among other parts case hardened are bushings for roller bearings (ground after treated); links and chains for conveyor

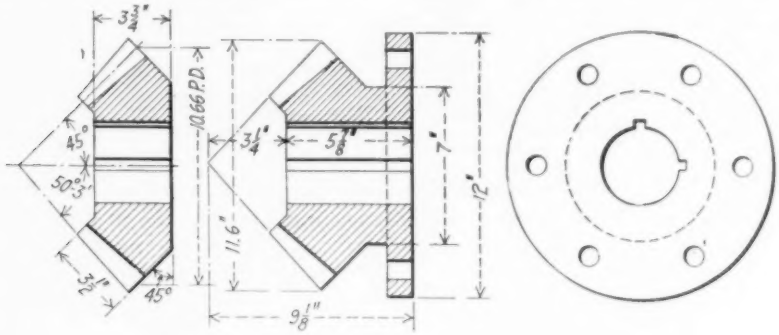

FIG. 34 GEARS FOR 24-IN. MILL TABLES; FORGINGS, 0.08 TO 0.12 PER CENT, CARBON STEEL. ABOUT 24 HOURS REQUIRED FOR ⅛ IN. PENETRATION

chains (very light penetration, about $^1/_{64}$ in.); and valve motion parts and connecting rod slides for locomotive repairs.

The gears or other parts to be treated are placed in round or square boxes and packed with bone black, using about three-quarters old to about one-quarter new material. The boxes are then sealed with clay and placed in the furnace where they are heated by natural gas to a temperature of about 1800 deg. fahr. The time required to heat properly varies from 12 hours to 30 hours, depending entirely on the size of the parts being treated and the amount of penetration desired. A great amount of the work requires about 20 to 24 hours from the time the furnace is lighted until the charge is ready to be withdrawn and quenched. This will give about ⅛ in. penetration which is the depth reached on most of the gears.

On light work the charge is usually allowed to cool before it is taken out of the carbonizing material when it is reheated to

about 1400 deg. fahr. and quenched in water. Nearly all of the gears and other heavy work are quenched in water direct from the packing box, a method which gives very good results and saves the cost of reheating. The heat in the gear at the time of quenching in this case is also 1400 deg. fahr. as near as the operator is able to judge with the eye.

It is found necessary to grind the bores of all gears after hardening as the bore is usually slightly out of round.

Boxes made of 1 in. plate steel will last for about 15 times in the furnace before they become too thin from frequent scaling.

The furnace used is of very simple construction, with two heating chambers each being supplied with two natural gas burners. No trouble whatever is experienced in maintaining an even temperature of 1800 deg. fahr. throughout the time the charge is in the furnace. The time required to bring the cold charge up to this temperature requires from 4 to 6 hours.

A diagram of the furnace used is shown in Fig. 31, and drawings of the pieces case hardened in Figs. 32 to 34.

THE AUTHOR. I desire to thank Mr. Benj. E. Bosler, Dr. Albert Sauveur, Dr. John A. Mathews and Mr. Robert R. Abbott for their kind discussions of my paper.

INVESTIGATION OF EFFICIENCY OF WORM GEARING FOR AUTOMOBILE TRANSMISSION

By Wm. H. Kenerson, Published in The Journal for September 1912

The paper describes a series of tests made to determine the efficiency of three types of worm gearing intended for use in automobile transmission, and at the same time a series of tests to determine the effect of continuous running Data regarding the shape and construction of the gears are given and the results tabulated and also expressed in graphic form. The results indicate a high efficiency and large carrying capacity.

DISCUSSION

Elmer A. Sperry. Question was raised as to the correctness of the evidence contained in the paper that the coefficient of friction decreases with increase of pressure. Within the past year the writer has conducted some interesting experiments on two large gyroscopes with oil bearings and running up to about 50 ft. per sec. with loads varying through a range of about 3000 per cent upon the lower half of the bearing and more than this on the upper half. Upon the lower half of the bearing the actual load ranged approximately from 2200 lb. to 65000 lb., whereas on the upper half of the bearings the load varied from zero to 60000 lb. This pressure could be applied at will, practically rising and falling in the form of a sine curve between the minimum and maximum.

The coefficient at gravity load was about 0.008, and for the highest load about 0.0036 to 0.004, as nearly as it can be determined. The writer's experience has invariably been that as the pressure would increase the coefficient would come down under the conditions named, the apparent range being somewhat in excess of 100 per cent. The results being entirely concordant and dealing as they did with large quantities, they may be con-

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Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

sidered as reliable and possibly contributing farther to our knowledge on this extremely important subject.

The remarks of Mr. Kent regarding the area of contact between worm and wheel being unknown as to influencing the coefficient of friction are not quite appreciated. Is it not possible the efficiency would be quite independent of the area actually involved? For instance, in journals above referred to, which were ordinary oil bearings provided with excellent oil circulation employed for the twofold reason of lubrication and cooling, it was observed that after 160,000 precessions of these gyros, involving very heavy pressures on the journals, that there was an entire lack of evidence of metallic contact or even that only a small portion of the entire area had ever been involved in sustaining these loads. For instance, one photographic record shows that only about 20 per cent of the projected area had ever been employed in the actual work as the original tool marks are present over the remaining surfaces.

W. C. Marshall. I would ask why the efficiency increases with the increase of load and speed, and why it is greater on the first and second speeds than on the direct drive. In the case of first and second speeds other gears are introduced and the efficiency should be less. In some cases it is greater with other gears introduced than with the direct drive. The rubbing velocity at lower speeds is less, but Mr. H. Kerr-Thomas of the Pierce-Arrow Company definitely states that in all his tests the efficiency does not vary appreciably between low and high speed with varying loads. The efficiency depends on the frictional resistance which varies with the square root of the velocity, and inversely as the pressure on the teeth. With an increase of pressure on the teeth and the velocity uniform there would be a reduced coefficient of friction. But if the velocity is increased and the pressure uniform the numerator of the frictional coefficient will be increased and consequently the resistance. If both quantities are varied (the denominator and the numerator) the result will remain nearly constant. Of course, this does not apply to extremely high speeds.

In the author's tests, however, the efficiency decreases in several cases with increase in load and speed, which I do not understand. It seems to point to the destructive coefficient which comes into play at high speeds and large loads. This coefficient is the prod-

uct of the pressure and the velocity and the tendency is for it to cause heating, which is shown in these experiments, as the oil becomes thinner and allows metallic contact, which reduces the efficiency.

It seems to me that the coefficient of friction in these experiments is rather high for a large load, as indicated by the rising temperature of the oil, and I have made one or two calculations to find out what this coefficient was, taking the figures given in the first line of Table 1. From the specific heat of the oil, the weight of the oil, and the number of heat units given to this oil in 6 minutes, I find 131 B.t.u. were given to the oil in 1 minute. Substituting that in the expression $H = \frac{p\mu V60}{J}$ for heat units in terms of the pressure, coefficient of friction, velocity and Joules' equivalent, the coefficient of friction comes out as 0.033. Working with that coefficient, which is rather large, the efficiency of these gears would figure out as 93 per cent $E = \frac{1 - \mu \cot a}{1 + \mu \tan a}$. It did not figure out anywhere near 93 per cent in this case. If Unwin's recommendation for the coefficient of friction = 0.002 is used in such cases, the efficiency will be in the neighborhood of 0.996. Mr. Thomas uses the same one in making calculations on worm gears, in which case the efficiency comes out at 0.996 per cent, which is a great deal higher than any of the experiments shown in the paper. The angle a or the helix angle is 38 deg.

Bevel gears afford such a high efficiency that it does not seem at all advantageous to use worm gears in driving automobiles unless the noise is a consideration. I would like to know if there was noise in connection with the test on bevel gears. That is an important point, especially if there is any resonant quality to the support.

In a test made on worm gears by Frank Burgess a curve of efficiencies is given which, using small h.p., runs almost in a straight line from 1 h.p. up to 3 h.p., where the efficiency is 93 per cent, then rises in the case of 4 h.p. to 95 per cent, and then begins to drop at a steady rate to 91 per cent at 8 h.p. Professor Kenerson's experiments do not show anything like this. There is no drop; always a rise. But there must be a point where the drop takes place, and I would like to see some results to show it.

The automobile transmission is important and it should be ascertained where the efficiency decreases. Also there must be high efficiency at low speed, since nine-tenths of the time automobiles are running under reduced power, and if the efficiency is very low it does not pay to use worm gearing.

Mr. Kerr-Thomas has proved that under certain conditions, such as trucking, the efficiency is just as high at low speeds as at high. Professor Kenerson does not agree with him at all, and I would like to get an expression of opinion from other members of the Society in regard to this point.

WILLIAM KENT said he would like Mr. Kenerson to give some theoretical reason why at uniform speed of rotation and increasing pressures, and consequently increased horsepower, the efficiency increases. It might be possible in starting on low speeds where the worm gears were imperfectly polished, that they were not as smooth as they should be and that the viscosity of the oil was greater at the low temperatures, but it is improbable that either of these causes would be sufficient to account for the lower efficiency at low pressures.

In regard to calculating the coefficient of friction, Mr. Kent saw no way that it could be done, because it was impossible to calculate the area of the surface that is subjected to pressure, that is, the area of contact.

L. B. TAYLOR. Mr. Kent called attention to the fact that the coefficient of friction has usually been considered to increase with the increasing specific pressure while the experiments in question indicate the reverse.

The laws governing copiously lubricated surfaces as determined by Petroff and given in the Hütte, 1911 edition, Vol. 1, Page 244, are as follows:

The coefficient of friction varies

a directly as the coefficient of the internal friction of the oil used at the temperature prevailing

b directly as the relative velocity of the rubbing surfaces.

On the other hand the coefficient varies

c inversely as the actual mean thickness of the layer of oil between the rubbing surfaces

d inversely as the specific pressure exerted between the contact surfaces

e at constant temperature the thickness of the layer of oil is inversely proportional to the square root of the specific loading of the surfaces in contact.

Since these laws were discovered the specific pressure allowed on steam turbine bearings has been increased 50 per cent.

THE AUTHOR. Referring to Professor Marshall's remarks, his understanding that the use of speed gears will affect the efficiency is incorrect. The dynamometer is placed between the change gears and the gear under test.

In comparing the results of the Burgess test with those under consideration, it should be borne in mind that the gears were tested under very light loads. Mr. Kerr-Thomas' statement that under certain conditions, such as trucking, efficiency is as high at low speeds as at high, undoubtedly refers not alone to the worm gearing but to the whole machine.

This statement is undoubtedly true because of the fact that the power lost in the tires of an automobile is much in excess of that lost in the transmission, and, of course, decreases with the speed. The question raised by both Professors Marshall and Kent regarding the decrease in coefficient of friction with the increased load is referred to and answered by others in the discussion.

There are so many factors to be considered that I believe it impossible to calculate a coefficient of friction as suggested by Professor Marshall.

Professor Kent's question regarding the reason for increased efficiency with the load is answered by the fact that the friction does not increase directly with the horsepower.

EXPERIMENTS WITH NORTH DAKOTA LIGNITE IN A STEAM POWER PLANT AND A GAS PRODUCER

By Calvin H. Crouch, Published in The Journal for December 1912

ABSTRACT OF PAPER

The North Dakota lignite fields cover approximately one-half of the State, or about 35,000 square miles. According to the State Geological Survey report, there were known to be in 1908 twenty-one workable seams of this coal in the southwestern part of the State, varying from 4 to 35 ft. in thickness and found in from 1000 to 1300 ft. of strata.

In this paper are reported some preliminary experiments showing the physical properties of the coal and the results when subjected to heat and the drying action of air; also two evaporative tests and 18 gas producer power plant tests, in which the coal was used as it came from the mine, except that it was broken so as to be charged easily into the gas producer.

The results of the evaporative tests, though not as satisfactory as could be desired, were interesting and instructive, indicating the possibilities of its use for such purposes and the improvements needed in furnace operation to burn it properly. The producer plant tests were highly satisfactory, showing that the coal could thus be utilized without special treatment and that the gas operated satisfactorily in the gas engine, giving a coal consumption in some of the longer tests of about 6½ lb. of coal as fired per kw-hr. at the switchboard for power available for outside purposes. If the power consumed by the gas scrubber was reduced to as small an amount as possible and the generator had been operated at more nearly its rated capacity, the results would have made a much better showing.

DISCUSSION

A. M. Levin. These experiments are interesting and instructing in so far as they deal with the nature of the fuel in general, and with its evaporative qualities; but in so far as they

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Presented at the Annual Meeting, December 1912, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

deal with lignite producer gas they are in no way fair tests of the fuel for producer use. The author himself doubts that they are; and his caution, that doubtless under more favorable conditions better results could have been obtained, may serve to offset to some extent the unfavorable impression the extraordinary test figures are bound to give.

One fact which the evaporative tests bring out is that under the boiler the lignites are only the poorest kind of fuel for the reason, if for no other, that they call for something like twice the boiler capacity any ordinary steam coal would require. Another fact about the lignites which the experiments fail to bring out is that as producer fuel they are ideal. Some lignites have proved to be and others, that as yet have not, should be given a fair trial. The chief object with the gas producer is, or should be, the handling of poorer grades of fuel among which the lignites must be counted.

Of the 18 producer tests of the Grand Forks' series there is but one that shows a reasonable fuel consumption per unit output. Mr. Crouch generously puts the blame for the shortcoming of the tests on a presumed inexperience of the experimenters; yet it seems entirely more likely that the blame should be laid to the employment of a wrong type of gas generator. There is not the slightest doubt but that the down-draft principle is wrong with respect to lignite fuels. These fuels, as the experiments bring out, disintegrate when heated in the fuelbed, so that by the time they reach the hearth of the generator they are very fine. When, therefore, in the down-draft producer the fine fuel becomes intermixed with the ashes which form in the greatest quantity at the top of the fuelbed, it should naturally be expected that the bed would become somewhat compact. Consider for a minute that all the fine loose particles in the fuelbed act in the way of so many small valves that tend to seat themselves over the interstices between the grains of fuel and it must be evident that to draw the gases downward in the direction in which these valves close is wrong. Instead, the draft should be upward, in which direction these valves can lift.

Unfortunately, the amount of tar separated in the cleaning of the gas is not recorded. This item would have been interesting for the sake of comparison with what can be accomplished by the up-draft producer in the way of fixing the tarry products of the

fuel. However, when some tar will have to be removed from the lignite gas whatever the type of the producer, it would not pay just for the sake of producing a somewhat smaller percentage, to ruin the gas process entirely by adhering to the down-draft principle. An attempt to run the producer so hot as to fuse all the ashes into clinkers would normally result in a leaner gas and a loss of sensible heat in the extremely hot gases. As ordinarily arranged, the power gas producer should be run consistently cool and with a slow current through the fuelbed. There is a time element involved in the breaking up of tarry hydrocarbons as well as in the reduction of the CO_2 gas.

In order to gain a better idea of what can be obtained in the way of returns by the use of lignite in the power gas producer it may be of interest to compare Tests Nos. 17 and 18 of the Grand Forks' series with one of the Bureau of Mines experiments at the Norfolk experimental station on a North Dakota lignite of identically the same quality as the fuels used in these tests; and also with a test on a Washington lignite, which the writer had occasion to make some years ago at Olympia, Wash. This test was fully described in Power[1] and it may be of interest because of the fact that although the fuel was quite high in ash, it proved by the use of a singularly suitable producer to give a high efficiency.

Test No. 17 of the Grand Forks' series is chosen because it is the best of the entire series, and Test No. 18 because it is rather poor, though not the poorest. The proximate analyses of the fuels used in the tests referred to were as given in Table 3, and the results obtained as in Table 4.

In the Olympia and Norfolk test figures allowance has been made for steam supplied to the producers.

The excessively high suction on the gas system of the Grand Forks' plant clearly indicates the real cause of the poor performance of the plant. Of the various losses accountable to this difficulty the following are of importance:

Direct loss due to increased resistance on the engine piston.

Loss due to inefficient combustion and reaction because of excessively high current velocity through the fuelbed, resulting in a lean gas.

Loss due to a reduced engine efficiency because of lack of density of the lean gas in the cylinder.

[1] December 27, 1910.

TABLE 3 PROXIMATE ANALYSES OF FUELS USED IN TESTS

	Fuel	Moisture	Volatile Matter	Fixed Carbon	Ash	Heat Value per lb., B.t.u.
Grand Forks, Tests Nos. 17 and 18....	N. D. lignite	23.35	33.9	38.4	4.35	8400*
Norfolk Test No. 2.....	N. D. lignite	39.56	27.78	26.3	6.36	6802
Olymphia.....	Washington lignite	16.2	28.90	32.1	22.8	7560

* The fuel value of this lignite is not given, but it was evidently quite high; an estimate gives about 8400 B.t.u.

TABLE 4 RESULTS OBTAINED IN UTILIZING FUELS IN POWER GAS PRODUCER

	Gas Analysis						B.T.U. per Cu. Ft.	Economy Coal as Fired per B.T.U-Hr.	Gas Pressure, Inches of Water		Tar Per Cent Weight of Fuel
	CO	CH_4	H	O	CO_2	N			Leaving Producer	Entering Engine	
Grand Forks, Test No. 17.....	10.62	4.2	18.97	3.8	6.08	56.25	152.7	2.8	−4.7	−26.9	....
Grand Forks, Test No. 18.....	11.70	4.77	8.04	3.7	8.59	63.18	115.4	3.47	−7.5	−28.8	....
Norfolk, Test No. 2.....	20.90	4.85	14.33	0.23	8.69	51.00	188.5	2.23	2.1	0	3
Olymphia.....	17.2	4.70	24.70	0.6	11.2	41.6	184	1.75	−1.75	− 2	7/8

Loss because of a highly increased power requirement in cleaning the rarified gas.

The excessive suction caused evidently also a considerable leakage of air into the gas system. This, however, may only apparently have affected the heating value of the gas.

The Washington fuel gave a perfectly clean ash, entirely free from coal or clinkers, but the North Dakota fuel used in the Norfolk test is reported to have clinkered some. The cause may have been that the producer, in order to maintain a full load on the engine, was run somewhat above its capacity. Naturally a lean coal, as lignite, will require a somewhat greater producer capacity than a richer fuel.

THE AUTHOR. I appreciate the generous remarks of Mr. Levin, but I firmly believe that a more experienced person would have secured better economic results in the producer gas tests. It is not claimed in the paper that the suction down-draft producer is the type of gas generator best suited to the utilization of North Dakota lignite. Before installing this experimental unit in 1910, I secured information and advice from a large number of gas producer manufacturers, and found but very few who made producers in capacities of 50 h.p. or under, which they would guarantee to handle lignite satisfactorily. There was no question about large producers of other types handling this fuel, but I wanted a plant approaching in size that which might be installed in a small town or one large enough to demonstrate that the coal could be used in a small isolated plant of the producer gas type. The state of North Dakota has numerous small but rapidly growing towns or villages which are, or soon will be, requiring electric lighting and pumping plants. The problem with them is what kind of a plant should be installed: so that this was regarded as an appropriate problem for investigation in North Dakota. In installing this unit I acted upon the advice given by some of the most prominent gas producer manufacturers, one of whom was at the time experimenting with a lignite producer and who, I understand, has since perfected one, but I am not aware that his company builds them in small sizes.

In connection with the statement that exceptional economic results are not shown, I would state that it was not expected that

exceptional results would be secured. I wanted to show that the coal could be utilized profitably in that size of producer, and I believe I succeeded.

As stated in my paper a larger amount of scrub water was doubtless used than was necessary with the result that the power consumed by the scrubber was greater than was necessary. Had this have been reduced to a minimum, the coal consumption per kilowatt-hour available at the switchboard for outside purposes would have been materially reduced.

Furthermore, the refuse which passed through the grate was larger than was necessary, due to unnecessary shaking. This refuse was all considered as waste, while as a matter of fact it should have been recharged into the producer and have been more completely burned. It was not thought wise to do this while conducting the tests, but in subsequent tests this refuse was refired with good results.

There was not enough tar to warrant its being saved. It collected in the bottom of the pit mixed with ash and fine particles of coal which were drawn into the condensing chamber and washed into the pit along with the tar, etc.

Concerning the statement of Mr. Levin relative to the lignite being a poor steaming coal requiring a large boiler, I do not think the tests reported indicate it, but rather that a boiler utilizing this fuel in its furnace needs a large amount of grate surface, a strong draft, and a special furnace adapted to the burning of a fuel rich in volatile matter.

I was not trying to prove that this fuel could be used in a producer gas plant of 250 h.p. or over, for the United States Government had done that, but I wanted to prove that it could be used profitably in smaller sized plants such as might be installed in a small town or manufacturing plant, and in this I think I succeeded.

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

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The Editor will be pleased to receive inquiries for further information in connection with articles reported in the review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

American and British engineering papers are from time to time reprinting articles from this Review. In accordance with the policy of the Society, all that is printed in The Journal is free to the entire engineering profession, and all that tends to extend the usefulness of the Foreign Review beyond the limits of the present number of the readers of The Journal is heartily welcomed.

THIS MONTH'S ARTICLES

This month several articles were considered important enough to deserve somewhat longer abstracts than usual: Equivalent Opening of a Ventilating System, by Dr. Kloss, shows that the use of such a method is justified neither by theoretical nor by practical considerations; instead of an equivalent opening, the author proposes to use a resistance coefficient, and derives for a ventilating system a law similar to Ohm's Law. To the same class belongs Dr. Harm's article on a system of testing compresed air machinery, a subject on which, notwithstanding its great importance, extremely little has been published. Mr. Schimanek's article on the six-stroke cycle type of engine is interesting in that it expounds the advantages that can be derived from using cycles of more than four strokes, or moving in a direction opposite to that taken in the early days of the development of the gas engine by Dugald Clark and others. Professor Poeschl's article on the calculation of stresses in rotating discs is, it is believed, the first application to this problem of W. Ritz's principle of variations, on which hardly anything can be found in current engineering literature. Finally, the attention of steam engineers in general and steam turbine engineers in particular is called to the article of Loschge on supercondensation, explaining some apparent contradictions in the phenomena of flow of steam through nozzles which have hitherto baffled such experimenters as Bendemann and Christlein.

In the section of aeronautics will be found a plausible explanation of what is known as an "airhole," as well as a table show-

ing the relation between the speed of an airship and height of sag through an airhole. Air machinery engineers will be interested in data of tests of a German reciprocating compressor plant, as well as a description of its valve gear. A new flue dust catcher is described in the section Firing. It may be mentioned in this connection that while lack of space does not permit giving descriptions of many interesting minor appliances appearing in Europe, an attempt is made whenever possible, at least to mention such as embody a more or less novel principle of operation. New types of stuffing box and of cooling element are described and illustrated in their respective sections, as well as the use of cast-steel rolled flanges for high-pressure piping, a problem which appears to be attracting considerable attention in Germany owing to the growing number of accidents due to failure in flanges in high-pressure piping. The description of compensating pipe joints in the same section will also be of interest in this connection. The Boettcher power counter, really an integrating attachment to a steam indicator giving direct readings of the output of an engine, is likewise described and illustrated.

While considerations of space do not permit as full abstracts as might be desirable, an attempt is made to supplement the information given by means of Supplementary References, to which attention is here directed.

Aeronautics

RESISTANCE OF AIR AND EXPERIMENTS ON REDUCED MODELS (*La résistance de l'air et les expériences sur les modèles réduits*, E. Jouguet. *Revue de mécanique*, vol. 32, no. 1, p. 9, January 31, 1913. 21 pp., 2 figs. *gt*). A general review of the applicability of experimental data obtained on reduced models to the design of airships. The author shows that while in general data obtained from experiments on models may be used for the design of larger types, strict attention must be paid to *perturbations:* (*a*) To correct for the error due to viscosity alone, the experiment on the model must be made at a speed which is to the real speed in inverse ratio of the products of respective densities by the lengths (the law of Osborne Reynolds). (*b*) To correct for compressibility alone, the experimental speed must be equal to the actual; and to correct for both perturbations, as well as for the difference in conductibility, the experiments must be made in air compressed in inverse proportion to the size of the model. This, however, is practically impossible to realize in a laboratory, and therefore it does not appear possible to satisfy at the same time the conditions of both (*a*) and (*b*).

"AIRHOLE" AT LANDING (*Das "Luftloch" bei der Landung*, E. Heinkel. *Der Motorwagen*, vol. 16, no. 4, p. 91, February 10, 1913. 1½ pp., 1 fig. *ptA*). Airmen usually try to land against the wind, when the relative velocity of the machine with respect to the earth is as low as possible. There is, however, an

element of danger in this, because the velocity of the air at the surface of the earth is not the same as at some elevation from it, and the air may be perfectly still at the ground level while at a comparatively slight height there may be a wind of some 10 m (32 ft.) per sec. This is due to the protection afforded the lowest layers of air by the unevenness of the earth surface.

If a flyer runs against a wind of 10 m per sec. with an absolute velocity of 25 m per sec., his relative velocity is 15 m per sec., and when he suddenly enters a stratum of still air, his velocity remains only 15 m per sec., which is not enough for planing; as a result he hits the ground with a thud, having struck an *airhole*. Such airholes may be met, especially in turbulent air, away from the earth surface as well, whenever the ship strikes a region of currentless air surrounded by windy air: in that case, however, the danger is somewhat less, because the ship has time to cross it, and meet the wind again. *In landing* it is, however, always a *safe thing to select a fully open place where there is nothing to keep the wind out*. The only way to protect himself against the airhole danger in landing is to land with the engine throttled, and as soon as an airhole is felt, to start the engine again (this advice should be used with judgment, and only when the airship is not too near the ground).

It is an interesting fact that the height of fall through an airhole is directly proportional to the velocity of the airship. Let G be the weight of the apparatus; v the velocity of the airship in still air; v_1 the wind velocity; h the height of fall. Further, let $v_1 = 10$. When the ship is in air having $v_1 = 10$, its kinetic energy is

$$A_1 = \frac{G\,v^2}{2g}$$

where $g = 9.81$. When the ship passes into the air having $v_1 = 0$, it loses some of its kinetic energy, which then becomes

$$A_2 = \frac{G}{2g}(v - v_1)^2$$

The difference between the values of A_1 and A_2 indicates the kinetic energy A required to bring the airship back to the speed that would allow it to float in the lower still air stratum. In this case $v_1 = v - 10$, which gives after substitution:

$$A = \frac{10\,.\,G}{g}(v - 5)$$

What is wanted, however, is to establish the relation between v and h. When a ship of weight G falls through h, a kinetic energy $A = G\,.\,h$ is liberated, and therefore Gh may be substituted for A in the preceding equation, which finally gives

$$h = \frac{10}{g}(v - 5),$$

But g is approximately equal to 10, and therefore

$$h = v - 5$$

may be accepted as being approximately correct. This equation shows that the height of fall through an airhole increases with the speed of the airship, and that it is independent of the weight of the airship (the latter because G does not figure in the equation for h). The author calculated in Table 1 the height of fall through an airhole due to the ship coming from air moving at 10 m (say 32 ft.) per sec. into still air, as functions of the speed of the airship.

COMPETITION FOR THE ROYAL PRIZE FOR THE BEST GERMAN AVIATION ENGINE (*Der Wettbewerb um den Kaiserpreis fur den besten deutschen Flugzeug-*

motor. Deutsche Luftfahrer-Zeitschrift, vol. 17, no. 3, p. 49. 6 pp., 14 figs. *de*). Description of the testing laboratories and methods to be used in this competition, as well as some of the engines that will take part.

Air Machinery

THE EQUIVALENT OPENING OF A VENTILATING SYSTEM AND THE CHARACTERISTIC CURVES OF A FAN (*Die gleichwertige Öffnung einer Luftanlage und die Kennlinien eines Ventilators*, Dr. -Ing. M. Kloss. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, no. 52, p. 2095, December 28, 1912, 7 pp., 10 figs. *etA*). To compare two fans, the actual resistance of each of the respective ventilating systems is replaced by an artificial one, such as a restricted (throttling) opening. This can be done because, as known, for a given opening the static pressure h_1 varies with the square of the volume of air V, so that the ratio $\frac{V_1}{\sqrt{h_1}} = \frac{V_2}{\sqrt{h_2}}$ is constant for a given throttling opening. The author passes then to the con-

TABLE 1 SPEED OF AIRSHIP AND HEIGHT OF SAG THROUGH AIRHOLE

v in km	v in miles per min.	v in m	v in ft. per sec.	h in m	h in ft.
50	31	14	46	9	29.5
75	47	21	69	16	52.5
100	62	28	92	23	75.5
125	78	35	115	30	98
150	93	42	138	37	122

sideration of the equivalent opening, and shows the derivation of the equation

$$A = \frac{V}{\mu}\sqrt{\frac{\gamma}{2gh}}$$

where μ is the coefficient of contraction; V volume of air in cbm; γ specific weight of air in kg/cbm; h total pressure head; g coefficient of acceleration due to gravity $=9.81$ m/sec^2. For mine ventilation μ is accepted to be equal to 0.65, which makes $A = 0.395\ \frac{V}{\sqrt{h}}$. The *equivalent opening is therefore such an opening in a thin plate as offers to the air the same resistance as the entire ventilating system in operation.*

The author proceeds, however, to show that the restricted opening and equivalent opening as calculated by the above formula with $\mu = 0.65$ do not coincide when the volume of air delivered exceeds a certain limit. The value of μ is apt to be greater than 0.65 both for large and even for small openings, and, in addition to that, as the author found from his tests, it is not constant. The conception of an equivalent opening loses therefore its original physical significance, and becomes a purely mathematical quantity, which has not even the justification of practical utility, since it unnecessarily cumbers the calculations, and, not being of constant value, may easily lead to false results.

Instead of the equivalent opening, the author proposes therefore to use an-

other conception based on the law stated at the beginning of this abstract, viz., the pressure head required for a given resistance is proportional to the square of the volume of air. The resistance head of a ventilating system is:

$$h = \Sigma\ \zeta \frac{v^2\gamma}{2g}$$

where ζ denotes the head loss due to friction and v the velocity of air in m/sec., which may be further expressed by $v = \frac{V}{F}$ with F as sectional area of the air ducts at the point where the velocity v prevails. The volume of air V, equal for all cross-sections, can therefore be placed before the summation sign, and the above equation expressed in the form

$$h = V^2 \frac{\gamma}{2g} \Sigma \left(\frac{\zeta}{F^2}\right) \text{ or } \frac{h}{V^2} = \frac{\gamma}{2g} \Sigma \left(\frac{\zeta}{F^2}\right) = \text{const} = R$$

and from this the next step is to use the resistance coefficient R, constant for a given ventilating system, as the basis for calculating purposes, without introducing such an auxiliary quantity as an equivalent opening.

Air delivery, pressure difference, power consumption and efficiency of a fan have been usually expressed as functions of the equivalent opening; if one attempts now to replace the equivalent opening by the resistance factor R as an independent variable, a difficulty arises in that in the limit case (closed fan) an infinite magnitude enters into the calculation since for $V = \infty$, the resistance factor $R = \frac{h}{V^2} = \infty$. It is therefore more advantageous to draw the characteristic curves of a fan by plotting, at constant speed of the fan n, the static pressure h, power consumption P and efficiency as functions of the volume of air V. It has been established by numerous tests that the air volume is proportional to speed in revolutions, while the pressure is proportional to the square of that speed. As regards the power consumption, tests made at the testing laboratory of the Siemens Brothers Dynamo Works, Ltd., in Stafford have shown that the power consumption of a centrifugal fan, the external resistance being constant, varies as the third power of the speed in revolutions. This does not include power losses through friction in bearings. The external resistance being constant, the efficiency of a centrifugal fan is constant and independent of the speed. There is therefore for each fan a certain definite external resistance $R_m = \frac{h_s}{V^2}$ at which it works at its best efficiency, and that at any speed.

To determine the behavior of a fan under any conditions whatever, at least two characteristic curves have to be plotted, preferably those of pressure and power consumption (or efficiency) as functions of the air volume. Since the relation between air volume, pressure, and power consumption on one hand and speed on the other have been shown to be known when the external resistance is constant, it is further advisable to plot the curves with constant speed, but varying external resistance; when the speed is not constant, the data obtained may be always easily reduced to constant speed. In fact it is a good plan to take for each resistance two or three points at various speeds, reduce the data by calculation to the same speed and take the average of those values. This will help to obtain particularly smooth curves.

The author gives data of tests and characteristic curves for the Keith-Black-

man, Sirocco and Siemens fans, which cannot be reproduced here owing to lack of space.

TEST OF A RECIPROCATING COMPRESSOR PLANT AT THE DAHLBUSCH MINE, Shaft II/V. (*Untersuchung einer Kolbenkompressoranlage auf Zeche Dahlbusch Schacht II/V. Glückauf*, vol. 49, no. 5, p. 170, February 1, 1913, 4 pp., 10 figs. *de*). Communication of the Society for Boiler Inspection of the Mines of the Dortmund Mining District at Essen, Germany. The tests were made in November 1912. The compressor is of the twin-tandem type, with the high-pressure steam and air cylinders in series on the right-hand side, and the low-pressure cylinders similarly arranged on the left side, the steam pressure being directly transmitted from the steam to the air pistons by means of piston rods. The steam and compressor cylinders are centrally interconnected by heavy intermediate pieces, both connecting pieces and steam cylinders being provided with special feet resting on a foundation with a machined surface which permits the free motion of the engine backwards when expanding from heat. The valve gear of both cylinders is as shown in Fig. 1 A. The beginning and end of the suction, and cutting-off of the pressure period are regulated by means of slide valves, while the beginning of the overflow of compressed air is determined, dependent on the degree of compression in the delivery chamber, by means of large spring-loaded non-return valves situated on the front end of the slide valves and moving together with them. The slide valves are driven by eccentrics from the crankshaft. As the slide valve at the end of the compression period at the dead center cuts off the connection to the cylinder, the non-return valve joined to it has all the suction stroke duration for its closing, and, moreover, its closing is due not to the large difference in pressure on both sides of the valve, but to the comparatively slight action of the spring, with a perfect equality of pressure on both sides of the valve. Notwithstanding its long stroke it can therefore in the time allowed reach its seat gradually and, what is of material importance, without excess of air pressure on one side. The valve action, even at high speeds of rotation of the engine is therefore very smooth and noiseless. The installation of the non-return valve in connection with the slide valve has also the further advantage that the slide valve is not loaded on one side by the air pressure, and the valve gear does not do any compression work. Between the low and the high-pressure cylinders is a recooler consisting of a wrought-iron boiler with a system of brass cooling pipes and cast-iron covers.

The steam engine is built so as to use superheated steam, and has the governing so arranged that a practically constant pressure in the air piping may be maintained: for this purpose the speed of the engine may vary from 25 to 100 r.p.m. (this is done by means of a compressed air governor device not described in the article).

The mechanical efficiency of the plant is said to be at least 88 per cent, the volumetric efficiency, according to the diagram, at least 92 per cent, with a suction output of 9.2 cbm (325 cu. ft.) per i.h.p-hr.; the compressor was guaranteed to compress from atmospheric to 7 atmospheres gage 10,000 cbm (35,000 cu. ft.) at 70 r.p.m., and 14,000 cbm (49,000 cu. ft.) at 100 r.p.m., with a permissible output variation of 5 per cent.

Fig. 1 B is the diagram for the high-pressure, and C for the low-pressure steam cylinders; D and E are for the high and low-pressure air cylinders respectively, all drawn to a scale of 4 mm = 1 kg (1 in. = 13.97 lb.).

The article contains full test data for both the engine and compressor; abbreviated test data for the latter are given in Table 2.

Investigation of Compressed Air Apparatus (*Untersuchungen an Pressluftwerkzeugen*, R. Harm, *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 5, p. 179, February 1, 1913. 4 1/2 pp., 13 figs. *eA*). Moeller, Baril and others have attempted to determine by graphical and mathematical means the pro-

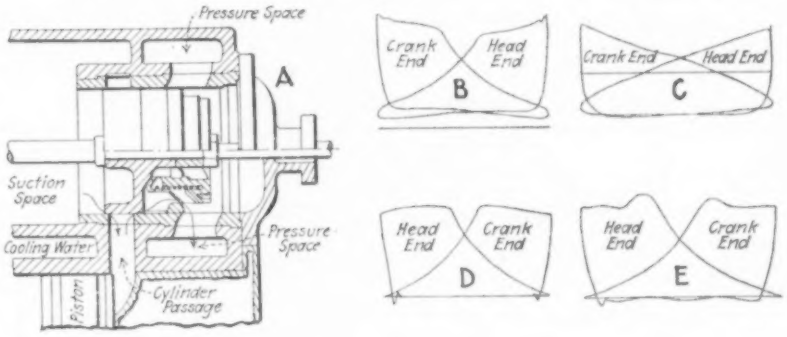


Fig. 1 Dahlbusch Mine Compressor Tests

cesses occurring in compressed air machinery, but, owing to the complicated nature of the processes investigated, these attempts cannot be considered to

TABLE 2 DATA OF COMPRESSOR TEST AT THE DAHLBUSCH MINE

	No. 1.	No. 2.
Speed of engine, r.p.m.	69.7	96.0
Engine output, h.p.	1075.6	1569.7
Average pressure of compressed air, atm. gage	7.03	7.1
Temperature of the air sucked in, deg. cent./fahr.	11.6/52.8	12.5/54.5
Temperature of air behind the low-pressure cylinder, deg. cent./fahr.	110.2/230.3	110.5/230.9
Temperature of air in cooler, deg. cent./fahr.	17.4/63.3	18/64.4
Temperature of air behind the high-pressure cylinder, deg. cent./fahr.	110.2/230.3	110.5/230.9
Output of compressor, i.h.p.	962.4	1399.3
Mechanical efficiency of the plant, %	89.5	89.1
Volumetric efficiency of the compressor, %	91.8	91.1
Air sucked-in per hr., cbm/cu.ft.	9363.8/ 330,549	13345.0/ 471,078
Air sucked-in per i.h.p-hr.	9.08/320	8.50/300

have given fully reliable results. Professor Schlesinger, director of the Laboratory for testing machine tools at the Berlin Technical High School, with the collaboration of the author of the present article, has therefore evolved experimentally a system of apparatus and processes for investigating compressed air tools. The description of this system forms the subject of the first part of the article by Dr. Harm. To indicate this kind of machinery by taking pressure-path diagrams is impossible, first because the piston of the striking tool cannot be used to drive the indicator drum, and second, because the speed of operation, varying from 800 to several thousands blows per minute is too high,

to make this method practicable. Only pressure-time diagrams can be taken, by means of an optical indicator, but they alone are not sufficient to permit the construction of the pressure-path diagram, since there is no way, as in the case of engines having a crank-drive, of automatically regulating the action of the piston. A second indicator process therefore becomes necessary, viz., one that would give a piston-path-time diagram, and this process the author illustrates and describes in full.

The test data were computed as follows. From the reading of the air meter or calibrating tank and stop-watch readings was found the actual amount of air consumed in a given time, and this was reduced to standard conditions (0 deg. cent. and 760 mm mercury) or V_{red}, by means of a calibrating table and the usual formula. From the speed in revolutions of an indicator disc is determined the peripheral velocity u of the disc, and by its means the time t_x for any point on the diagram. Of particular interest is the total time t of a piston period of operation, and the times t_r and t_h of the return and forward strokes, determined graphically from Fig. 2*D* (abscissae l, l_r and l_h). The number of blows $z = \frac{60}{t}$ is likewise determined thereby. The ordinates of the diagram represent, in natural size, the piston paths, the respective velocities being $v_x = u \tan v$ The following velocities have been selected, with their equations, as particularly characteristic for the action of the piston:

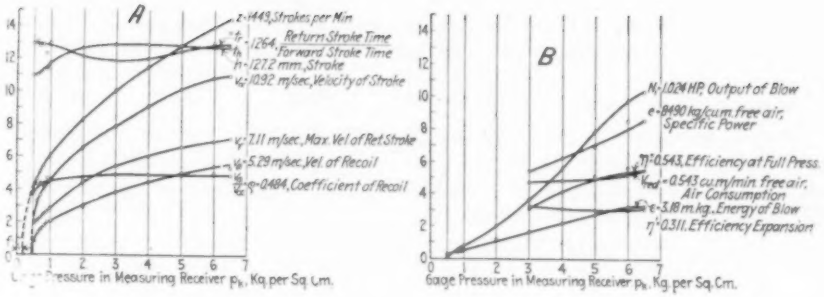
Velocity of blow $v_\alpha = u \tan \alpha$
Velocity of recoil $v_\beta = u \tan \beta$
Maximum velocity of return stroke $v_\gamma = u \tan \gamma$
Average velocity of return stroke $v_r = u \tan \delta$
Average velocity of forward stroke $v_h = u \tan \epsilon$

This shows that, to obtain the respective actual piston velocities, it is only required to multiply the trigonometric tangents of the angles by the peripheral speeds u. The ratios of these velocities to each other are also of considerable interest. Thus

$$\frac{v_\beta}{v_\alpha} = \frac{\tan \beta}{\tan \alpha} = \text{recoil coefficient } \rho$$

$$\frac{v_\gamma}{v_\beta} = \frac{\tan \gamma}{\tan \beta} \text{ and } \frac{v_\gamma}{v_\alpha} = \frac{\tan \gamma}{\tan \alpha}$$

For the capacity of this class of tools the following magnitudes are of importance: the energy of the blow $E = \frac{m}{2} v_\alpha^2 \text{mkg}$ (m is the mass of the part having a reciprocating motion); energy of recoil $E_r = \frac{m}{2} v^2_\beta$ and the energy which the piston gives up $E_a = E\,(1-\rho^2)$; output of blow $N_1 = \frac{E \,.\, z}{4500}$ in h.p., and corresponding to it $N_a = N_1\,(1-\rho^2)$. Since maximum ease of operation is usually required in compressed air tools, $\frac{N_1}{G_H}$ is also of importance: G_H is here the total weight of the tool.


A
z-1449, Strokes per Min
Return Stroke Time
1264, Forward Stroke Time
l-127.2 mm. Stroke
v₂-1092 m/sec, Velocity of Stroke
v₁-7.11 m/sec, Max. Vel of Ret Stroke
v₂-5.29 m/sec, Vel. of Recoil
e-0.484, Coefficient of Recoil
Gage Pressure in Measuring Receiver pₖ, Kg per Sq. Cm.
B
N-1.024 HP, Output of Blow
e-8490 kg/cu.m. free air, Specific Power
η-0.543, Efficiency at Full Press.
0.543 cu.m/min. free air, Air Consumption
e-3.18 m.kg., Energy of Blow
η-0.311, Efficiency Expansion
Gage Pressure in Measuring Receiver pₖ, Kg per Sq. Cm.

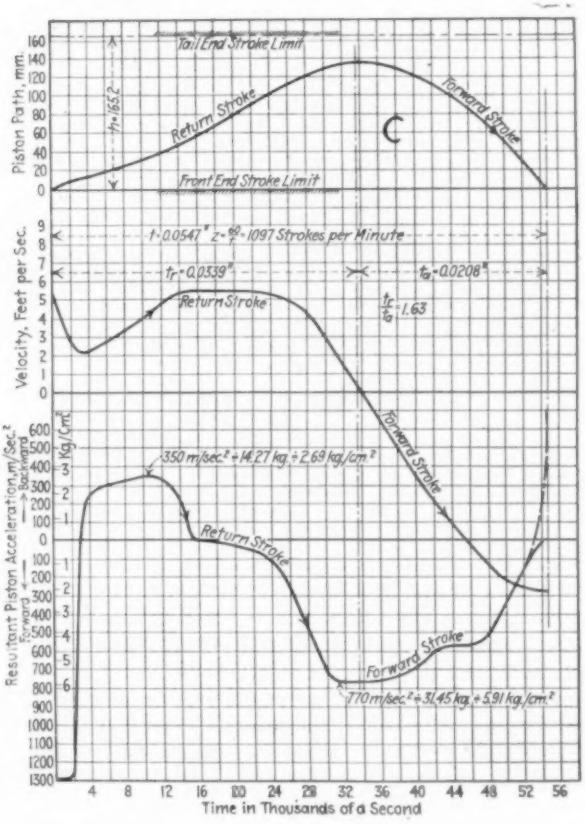


FIG 2 COMPRESSED AIR MACHINERY TESTS

Economy of Operation. Data as to the air consumption have little value unless the work done by the hammer is also considered simultaneously. The specific output of a compressed air tool may be expressed by

$$e=\frac{E \,.\, z}{V_{red}}, \quad \text{or} \quad e_a=e\,(1-\rho^2).$$

With these data for the utilization of compressed air, representing experimental values obtained by actual measurements, are to be compared theoretical values for the output, equally reduced to normal conditions and pressure p_2 kg/qcm. But with respect to this theoretical output the following distinction must be made: (*a*) the full theoretical output e' at perfect adiabatic expansion, and (*b*) the theoretical output e'' at full pressure, without the utilization of the expansion. The consideration of e'' is important because in many cases in practice no attempt is made to utilize the expansion, either so as to avoid the possi-

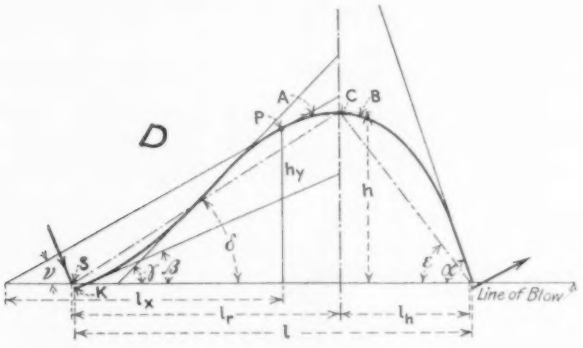


Fig 2 Compressed Air Hammer Tests

bility of cooling the hammer down to the freezing point, or in order to obtain, for the same weight, as high an efficiency of blow as possible. In such cases e'' represents the ideal value. The values $\eta'=\frac{e}{e'}$ and $\eta''=\frac{e}{e''}$ also represent important magnitudes in the estimation of a compressed air hammer.

Figs. 2A and B give data obtained from the tests of a compressed air hammer at various air pressures. The velocities and numbers of blows per unit time show very well the parabolic curves which the mathematical and mechanical reasoning lead one to expect.

A more thorough investigation of the processes inside the hammer by means of time-path diagrams may be made mathematically and graphically by methods similar to those shown in Fig. 2C where, by differentiation, are derived the velocity-time and acceleration-time diagrams. From these and the previously obtained path-time diagram may be finally derived the velocity path and acceleration path diagrams. This investigation on the whole has shown that the process used is an unusually reliable and interesting method of gaining an insight into the processes occurring in compressed air tools.

Firing

New Patented Flue Dust Catcher (*Neuer patentierter Flugaschen- und Staubfänger*, *Braunkohle*, vol. 11, no. 45, p. 726, February 7, 1913, 1 p., 2

figs. *d*). The disadvantage of the usual flue dust catchers is the loss in draft resulting from their use. The flue dust catcher of the Zeitzer Dampfkesselfabrik und Apparatenbauanstalt G. Schumann, of Zeitz, Germany, is claimed to reduce such losses to a minimum. The gases are led from the boiler to an expansion chamber (Fig. 3) of such proportions as to permit the solid particles to settle by gravity, owing to the decrease of the velocity of the gases carrying them. The chamber is provided with a number of settling cells arranged one behind the other as shown in the drawing, with their height decreasing in the direction of the flow of the gases, and having the rear wall, with its several grooves for receiving the settling

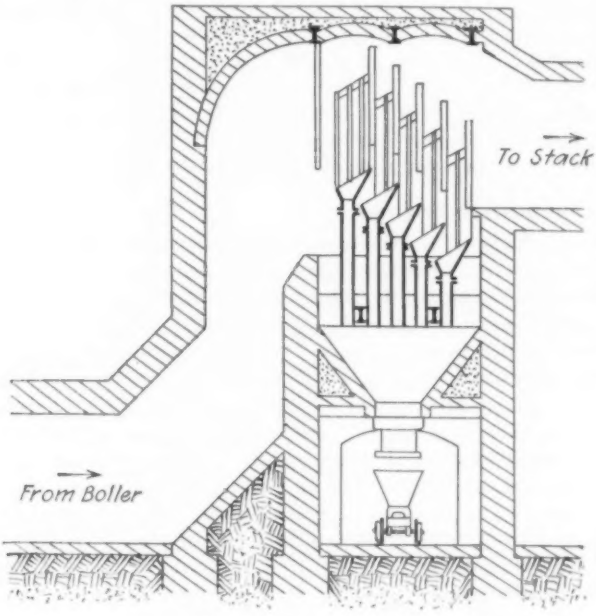


FIG. 3 GERMAN TYPE FLUE DUST CATCHER

dust, sloping in the direction of the flow of gases. By such an arrangement of the cells and lower wall the total section between the cells, or in the settling zone proper, is made equal to the section of the chamber itself, and the gases flow over the settling cells in small streams, at a low velocity and at an elevation above the cells proportional to their distance from one another. The solid particles have therefore to travel only a very short distance, and, with proper proportions of the device, each solid particle, no matter in what zone of the gases it may be, must separate out. As soon as it falls into a settling groove or cell, it is carried off by special piping to the ash collector, and cannot therefore be carried out again by the flowing gases. The moderate dimensions of the device permit its installation nearly everywhere.

Hydraulics

THE CONSTRUCTION OF FRANCIS BLADES IN ACCORDANCE WITH THE LORENZ TURBINE THEORY AND THEIR PROPERTIES (*Die Konstruktion der Francis-Schaufel nach der Lorenzschen Turbinentheorie und ihre Eigenschaften*, Bauersfeld. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, no. 51, p. 2045, December 21, 1912. 6 pp., 7 figs. *mt*). Lorenz has made possible the mathematical investigation of the theory of the turbine by replacing the accelerations in the blade surfaces by a constant field of force, so that the flow could be considered as if it were occurring with perfect uniformity about the axis of the turbine. This assumption is in full agreement with an assumption of an infinite number of turbine blades. The author starts from this theory of Lorenz and derives a graphical method for the design of turbine blades, and establishes the conditions which have to be observed in the selection of the inlet edge and length of blade. He indicates also the variations occurring in the flow through the rotor when the amount of water flowing and the speed of rotation vary. Thus he shows that in the Jonval turbine the angle of entrance along the entire inlet edge must be in excess of 90 deg. in order that the main flow be free from eddies.

Internal Combustion Engines

HORIZONTAL DIESEL ENGINES OF THE GERMAN AUTOMOBILE CONSTRUCTION COMPANY OF BERLIN (*Liegende Dieselmäschinen der deutschen Automobil-Construktionsgesellschaft, Die Gasmotorentechnik*, vol. 12, no. 11, p. 169, February 1913. 4 pp., 4 figs. *d*). Only vertical Diesel engines have been built as long as the Diesel patents were alive, because the manufacturers had enough orders and did not care to go to the expense and risk of developing a new type. Since then the horizontal engine has been made as reliable and smokeless as the vertical. In the engines of the German Automobile Construction Company the flywheel is on the camshaft side while the compressor is located horizontally on the other side of the engine frame. The advantage of such an arrangement lies in that a second cylinder may be built in on the far side from the flywheel, in which case all the valves of the second cylinder are taken care of by the valve gear of the first cylinder, with no additional camshaft, while the compressor is shifted to the off-side of the second cylinder. In addition it permits of the construction, without extra patterns, of twin two and four-cylinder engines, using both sides of the flywheels; in this case both camshafts are easily accessible. With three sets of patterns only seven types are built:

One Cylinder, H.p.	Two Cylinders, H.p.	Four Cylinders, H.p.
20	...	...
50	100	200
100	200	400

The machine with a larger number of cylinders is taken in preference to one of equal power with a lesser number of cylinders when a particularly high uniformity of running is of importance. To decrease the noise of air suction, the air is taken from the basement by a long pipe which has the additional advantage of always supplying the engine with fresh air free from oil vapors. To make the piston pressure on the guide face of the cylinder as low as in vertical engines of the same dimensions, the ratio

of connecting rod length to crank radius was increased. The article describes in some detail the valve gear and lubrication arrangement. The engine is started by compressed air. Cp. also the Standardization System of J. E. Christoph Co., *The Journal*, January 1912, p. 132.

THE FORMATION OF OIL DEPOSITS IN THE CYLINDERS AND BEARINGS OF STEAM AND GAS ENGINES (*Über Bildung von Ölrückständen in Zylindern und Lagern von Dampf- und Kraftmaschinen*, H. Schlüter. *Chemiker-Zeitung*, vol. 37, no. 22, p. 221, February 20, 1913, 2 pp. *p*). The author discusses a number of cases where *deposits* formed *in the cylinders and bearings* of various engines, and by comparing the analyses of the deposits and oils used, shows that in most of the cases where the trouble occurred the amount of mineral matter in the deposits was out of proportion to that in the oil, which proved that the fault was due not to the oil, but either, as in the case of steam engines, to carelessness in operation, or, with blast furnace gas engines, with poorly cleaned gas. Only under exceptionally unfavorable conditions of operation can lubricating oils free from solid matter form deposits through simple oxidation in the cylinders of steam and gas engines, as happens sometimes in compressor cylinders.

INCREASE OF OUTPUT OF INTERNAL-COMBUSTION ENGINES AND A NEW SIX-STROKE CYCLE ENGINE (*Die Steigerung der Leistung von Verbrennungsmotoren und ein neuer Sechstaktmotor*, E. Schimanek. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 4, p. 134, January 25, 1913. 8 pp., 18 figs. *dt*). The improvement of the output of internal-combustion engines may be sought along the following lines:

(*a*) Improvement of economic efficiency by better fuel utilization (the gases are subjected to a longer expansion, the volume at the end of expansion is equal to cylinder volume or that at the beginning of compression): has been proved theoretically and practically that, with increasing compression, beyond certain limits the advantages practically stop, and, e. g., in the case of constant-pressure engines, compression above 38 or 40 atmospheres does not improve the efficiency any more.

(*b*) Increase of the number of working strokes per unit of time. This can be done in two days: (1) by increasing the speed of the engine (speed above 200 to 300 r.p.m. does not improve the efficiency any more, while high speed always unfavorably affects the life of the engine); or by (2) the reduction of the number of strokes at which no work is done (double-acting and two-stroke cycle engines; a calculation is given to show how the efficiency of the two types compare with each other).

(*c*) Increase of the amount of air handled by the motor per fuel charge (by lowering the temperature of the air, reduction of the amount of products of combustion remaining in the working cylinder and filling up the space thus liberated by clean air, and by increasing the air pressure previous to compression).

The second of these methods is applied in the so-called scavenging engines, as well as to a certain extent in six-stroke cycle engines (for six-stroke cycle engines generally see Güldner, The Design and Construction of Internal Combustion Engines, New York, 1910).

In the case of a four-stroke cycle engine, the output may be increased by

supplying to the working cylinder compressed air from a special receiver in which the compressed air is replaced by a pump. The pump must then supply the entire air handled, and the dimensions of the working and pump cylinders depend on the desired pressure or improvement in the output; the pump, which works on the two-stroke cycle, must have a cylinder either equal to the working cylinder, if it is single acting, or of half its volume, if it is double acting, so that the ratio for the same output between the combined cylinder and pump volume for the improved and ordinary types of four-stroke cycle engines is for 2 atmospheres pressure in the first case $a = 1$, and in the second $a = 0.75$; for 1.5 atmospheres pressure a becomes respectively 1.166 and 0.913. Another way is to take part of the air from outside, and only supplement from the receiver. In this case the working process is as follows: the working cylinder at the first stroke draws in outside air, and at the end of the suction stroke, after the suction opening has been closed, the working cylinder is set into communication with the receiver, so that the air compressed by the pump flows into it and raises the pressure; this is followed by the usual compression, expansion and exhaust. If now the working cylinder takes in as much air from outside as from the receiver, then previous to compression (isothermic compression in the pump and instantaneous free-of-losses passage of air to the working cylinder at the dead center being assumed) the pressure in the working cylinder is 2 atmospheres and the output twice as large as in the ordinary four-stroke cycle engine. Since with a single-acting pump the total volume of the working and pump cylinders is $1 + 0.5$, the ratio a becomes $\frac{1.5}{2} = 0.75$; with a double-acting pump it is $a = \frac{1 + 0.25}{2} = 0.62$.

The thermal efficiency of such an engine is somewhat lower than that of an ordinary four-cycle engine, and the more so the smaller the size of the receiver because in the overflow of air, apart from acceleration and throttling losses, there are losses due to the flow of air from the receiver where it is at a high pressure, to the cylinder where a lower pressure prevails. But the efficiency of a four-stroke cycle may also be improved without introducing a separate air pump, but by applying a special process invented by the author. The essential part of this new process consists in making several suction strokes before each compression or expansion stroke. The air taken in before the last suction stroke is stored in a receiver up to the last suction stroke when it is conveyed to the working cylinder and there forms part of the explosive charge. This cycle may be of six or more strokes. In the six-stroke cycle shown in Fig. 4 A the sequence is as follows: stroke 1: suction of outside air, *A—B;* stroke 2: compressed air driven into the receiver, *B—C;* stroke 3: suction of outside air, *C—D;* between the third and fourth strokes the air flows over from the receiver into the working cylinder, where the pressure rises to about 2 atmospheres, *D—E;* stroke 4: compression of the charge, *E—F;* stroke 5: combustion and expansion, *F—G;* stroke 6: exhaust, *G—H.* With this process in six strokes twice as much air is handled as in a four-cycle engine in four strokes, and, for the same number of revolutions, the output is 1.33 times as great as in the latter type; not counting losses connected with the overflow of air, the same cylinder volume in the six-stroke cycle gives about 33 per cent more output than in the four-stroke.

In actual operation, however, this is not quite so. The conditions are the same as in a four-stroke cycle engine only during the first suction stroke, while previous to the second and following strokes the pressure in the compression space of the cylinder is that of the receiver, and the volumetric efficiency is therefore affected by the expansion of the air from the receiver pressure to the atmospheric. At the second and following (in engines of cycles higher than the six-stroke) suction strokes the volumetric efficiency can be good only when the compression space is not too large, and the

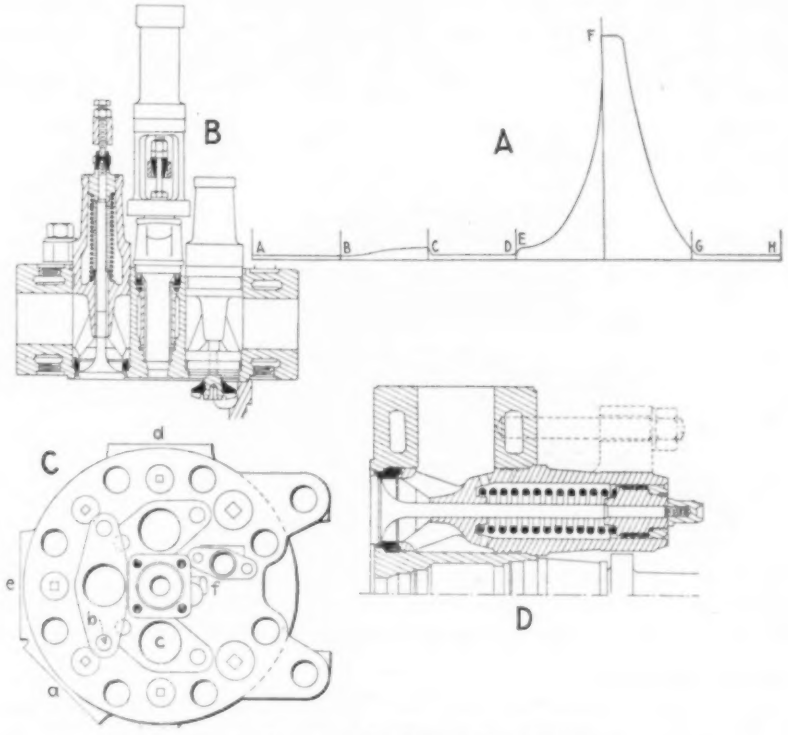


FIG. 4 SCHIMANEK SIX-STROKE CYCLE ENGINE

application of this principle is therefore limited to engines with a high compression pressure, that is, to constant-pressure engines.

As regards the ignition of the fuel only small amounts of heat can escape through the receiver walls, owing to the comparatively low temperature of the stored-up air and its low conductivity; the fall in temperature due to this loss of heat is further compensated for by the rise of temperature due to throttling. The final temperature does not therefore substantially differ from that of four-stroke cycle engines using similar pressures, and the final pressure need not exceed 60 atmospheres, as in the four-stroke cycle engine. Actually, however, only about 50 atmospheres are used, which makes a larger compression space necessary, and somewhat reduces the

thermal efficiency of the engine. As regards losses of heat to the cooling water, in the four-stroke cycle the cooling does no useful work during the suction and exhaust strokes, and affects the compression stroke but little. It affects harmfully the utilization of the fuel heat content only during the combustion and expansion strokes. In the six-stroke cycle there are five strokes during which the cooling water does no harm, and therefore for the same number of revolutions per minute the loss to the cooling water is less in the case of the six-stroke cycle engine than in the four-stroke cycle. The Schimanek engine working on the six-stroke cycle is shown in Fig. 4 B and C, and the overflow valve permitting the air to flow from the receiver into the cylinder between the third and fourth stroke, as explained above, in Fig. 4 D. The article contains full data of tests which cannot be given here owing to lack of space. The useful output of the new engine

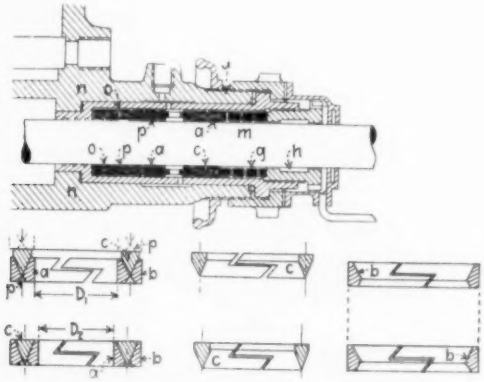


FIG. 5 GERMAN SELF-PACKING STUFFING BOX

(about 40 h.p.) was found to be 20 to 25 per cent in excess of that of a four-stroke cycle engine of similar dimensions. There are no data as to the first cost of the new type as compared with those now in existence.

Machine Elements

SELF-PACKING METAL STUFFING BOX (*Selbsdichtende Metallstopfbuchse*, H. Hirschlaff. *Zeits. für Sauerstoff- und Stickstoff-Industrie*, vol. 5, no. 4, p. 67, February 20, 1913, 2½ pp., 5 figs. *d*). Description of a new stuffing-box patented in Germany (D.R.P. no. 256,134). It is said to give an excellent packing for compressors, pumps, gas engines, etc., and to be self-adjustable within wide limits. The packing has three one-piece, slit and elastic rings *a*, *b* and *c* (Fig. 5). By tightening the gland *h* the central wedge-shaped rings *c* are displaced axially, and cause the rings *a* and *b* to press against the piston rod *m* or the stuffing box neck *n*. As a result, the internal rings *a* are radially contracted twice as much as the middle wedge-shaped rings, while the outer rings *b* undergo no change as far as the diameter is concerned, and are only successively displaced radially towards the gland. This in its turn results in a wide radial adjustability of the packing and, in connection with a good system of lubrication, leads

to a long life of the packing. The gland has to be tightened just enough to provide a fit at the maximum working pressure, since the rings are elastic. There is therefore no need for the usually applied excessive radial pressure which in most cases of operation serves no useful object.

The external bush *d* is required first owing to the slight height of the elastic rings, in order to provide a supplementary piece to make the dimensions of the stuffing box correspond to those of the other engine parts. In the second place it is useful in permitting the installation and removal of the stuffing box as a unit, and further as smooth a surface as possible is thereby given to the outer rings *b*. The characteristic feature of this stuffing-box construction is, however, its utilization of the liquid pressure as an auxiliary and automatically acting packing. This is done by means of the hollow intervals *p* enclosed airtight on all sides by the inner and outer rings *a* and *b* and the two contiguous wedge-shaped rings *c*. The pressure of the liquids which collect in these intervals gradually decrease in the direction of the atmosphere and produce, first, a direct radial

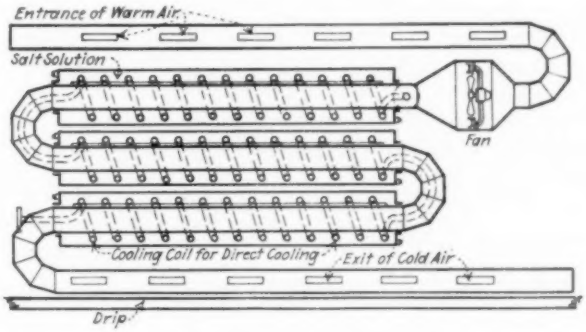


FIG. 6 FREUNDLICH COOLING ELEMENT

pressure on the packing rings *a* and *b*, and, second, a differential axial pressure on the wedge-shaped rings with respect to the packing rings, which in its turn improves the radial packing. This system of so-called *self-packing* is independent of the direction of pressure, and can therefore be used for vacuum. The article describes several types of stuffing boxes, of which only one is here shown (Fig. 5, for small high-pressure engines). It is said that only a very small amount of this system of packing has to be used where a considerable amount of other types had to be used formerly.

Refrigeration

A NEW TYPE OF UNIVERSAL COOLING ELEMENT (*Ein neuartiges Universal Kühlelement*, M. Hirsch. *Zeits. für die gesamte Kalte-Industrie*, vol. 20, no. 2, p. 36, February 1913. 2 pp., 2 figs. *d*). General discussion of the problem of maintaining dry air in the cooling rooms, and description of the new cooling element patented in Germany by the firm Freundlich. In this system (Fig. 6) the cooling medium circulates directly in the batteries

placed either in parallel or in series, but it gives up its cold not directly to the cooling room, but indirectly to a cooling medium which, according to the temperature used, may be salt solution, glycerin or alcohol. Through this cold accumulator is passed an air conducting pipe connected with a fan which sucks in the warm or outside air, forces it through the accumulator element, and brings it back into the room cooled and dried. The condensate which forms in the piping can of course be led out by means of drip pipes, and by connnecting the accumulator system with some source of heat, it is possible to provide for a rapid thawing off of the cooling pipes even at the room temperature below the freezing point of water. The relatively small volume of the accumulators makes possible a rapid and intensive cooling, which is accomplished very economically because large temperature differences between the evaporating medium, and the solution transferring the cold (such as salt solution) are here eliminated. The ratio of the direct area of evaporation and the area of cold transmission of the outer and inner pipes is proportioned in such a way that the temperature of the salt or other solution used instead is only about 1 deg. cent. (1.8 deg. fahr.) higher than the evaporation temperature of the cooling medium. As against plants with external evaporators and indirect cooling of the salt solution with its attendant temperature difference of about 5 deg. cent. (9 deg. fahr.), this gives a saving in power of about 15 per cent apart from the power and cold which is incurred by the additional circulation of the salt solution generally necessary. The amount of air circulating in the system may be so regulated as to obtain any desired degree of dryness, while the intensity of the air circulation provides for an energetic exchange of heat, and thus raises the efficiency of the plant.

Steam Engineering

New Boiler Feed for Low-Pressure Boilers (*Un nuovo alimentatore per caldaie a bassa pressione. L'Industria*, vol. 27, no. 8, p. 123, February 23, 1913. ½ p., 3 figs. *d*). Description of a new *boiler-feed regulator* for low-pressure boilers, such as are used in heating. Its main part is a pure rubber valve constantly immersed in water, so that the steam cannot exert on it its destructive action. The valve is acted upon by a float water level the axis of which follows the level of the water.

Use of Rolled Cast-Steel Flanges for High-Pressure Piping (*Die Verwendung von aufgewalzten Stahlgussflanschen für Hochdruckrohrleitungen*, H. Winklemann. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 7 and 8, p. 73 and 91, February 14 and 21, 1913. 6 pp., 11 figs. *dp*). The welded flange joint is always liable to produce local stresses at the weld, which may result in a lowering of the coefficient of safety of the plant. The rolled joint is both cheaper and safer. The cast-steel flange when properly made and annealed is much superior to wrought-iron one, but not every steel foundry can do such special work. There was some doubt as to whether the connection between the flange and pipe would be as lasting as in the case of wrought iron or Siemens-Martin steel, but the tests made at the Royal Testing Laboratory at Gross-Lichterfelde West

have shown the superiority of the cast steel. The superiority of the tested joint was due partly to its construction shown in Fig. 7 A, where attention is called to the fine grooves and the sharp-edged thread: by this means the working face between the pipe and flange, especially owing to the comparatively softer material of the pipe, is made much larger than is the case with the usual construction having only a few large grooves (Fig. 7 B). The article contains full data of the tests.

FLOW OF STEAM THROUGH ORIFICES (*Der Ausfluss des Wasserdampfes aus Mündungen*, A. Loschge. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, nos. 2 and 3, pp. 60 and 108, January 11 and 18, 1913. 12 pp. 38 figs. *ct.A*). Experimental investigation of the phenomena accompanying the flow of steam at high velocities through orifices such as occur in turbine practice. In 1907 Bendemann published his experimental researches in which he arrived at conclusions differing from the views generally ac-

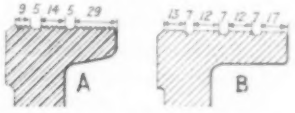


FIG. 7 ROLLED CAST-STEEL FLANGE FOR HIGH PRESSURE PIPING

cepted up to that time, and from what appeared to follow from the formulæ of St. Venant-Wantzel and Zeuner. Bendemann found that although the theoretical formula $G = \psi F \frac{P_1}{\sqrt{P_1 V_1}}$ is generally correct, the ψ-curves obtained experimentally for saturated and superheated steam coincide; and the experimental ψ-curve lies for values of $\frac{P_2}{P_1}$ from 0 to about 0.69 above the theoretical curve for saturated steam, and from there on up to $\frac{P_2}{P_1} = 1$ below that curve; the maximum value of ψ being 2.03 which is between the two theoretical values: 1.99 for saturated, and 2.09 for superheated steam. Bendemann tried to explain this discrepancy between the experimental values by supposing that k for superheated steam is considerably lower than 1.33, and is nearly equal to that for saturated steam. This has been disproved, however, by recent determination of c_p by Knoblauch-Jakob and the determination of the equation of state for steam by Mollier-Callendar from which it follows that k for superheated steam is nearly 1.3. The purpose of the author's experiments was to go over the Bendemann experiments and find out the cause of the discrepancy between his values and the theoretical, if there was such a discrepancy.

In the author's tests (fully described in the article) a bronze outlet opening as shown in Fig. 8 A was used; contrary to the practice of Bendemann, it was provided, however, in order to avoid contraction in all cases, with a long cylindrical part; for rounding off the opening parabolic curves were selected.

In his experiments the author found that: (*a*) both superheated and saturated steam have given practically *one* ψ-curve, and (*b*) although his curve had the same material characteristics as the Bendemann curve (maximum 2.035 as against 2.03 of Bendemann; below the theoretical curve at high back-pressure, and above it at low), there were also differences in that the point of intersection with the theoretical curve lies for saturated steam at $\frac{P_2}{P_1}$ equal about 0.80, while in the Bendemann curve it lies at about $\frac{P_2}{P_1} = 0.69$. For his curve the author recommends the Bendemann equation of an ellipse:

$$\psi = \frac{\psi_{max}}{1-\beta}\sqrt{1-2\beta\left(1-\frac{P_2}{P_1}\right)-\left(\frac{P_2}{P_1}\right)^2}$$

with $\psi^{max} = 2.035$, and $\beta = 0.570$ (instead of the Bendemann value $\beta = 0.545$).

The author ascribed at first this discrepancy to the influence of the interchange of heat between the steam and the orifice walls, in which he was partly supported by the work of Batho.[1] He made, however, a series of tests using an orifice with porcelain and sheet iron walls, and found that the curves thus obtained closely cover those previously obtained with the bronze orifice. This proved that the influence of this cause was not material. The author proceeded therefore to investigate, by means of small drillings in the walls of the outlet opening, the distribution of pressure inside the orifice (a full description of the method of test and precautions taken is given). The nozzle used is shown in Fig. 8 D and E, and was provided with a cylindrical extension 7 mm (0.275 in.) long, the center of the measuring hole being only 1.75 mm (0.069 in.) from the outlet edge. In all the tests with saturated steam the pressure in front of the orifice p_1 was maintained at 6.7 atmospheres absolute; the pressure at a point within the orifice is denoted by p_x and that behind the orifice by p_2. First the pressure ratios $\frac{p_x}{p_1}$ and $\frac{p_2}{p_1}$ were determined, and from them were derived $\Delta\frac{p}{p_1}$ the values of the differences between them. The values for two points inside the orifice are plotted in Fig. 8 C. They show material disagreement with the St. Venant-Wantzel theoretical curves, and moreover, as shown by Fig. 8 F, the curves obtained for various points in the orifice do not coincide at all with each other. The latter phenomenon shows that the pressure in the orifice and the process of pressure variation inside the orifice is a function of the length of the cylindrical extension of the orifice. It was further found that in a simple opening without a cylindrical extension the invariable pressure at the outlet edge is in the neighborhood of 0.60 p_1 and consequently somewhat higher than the theoretical value 0.577 p_1. Table 3 is an abbreviated reproduction of Table 1 of the original containing the pressures for which the coefficient of discharge has been

[1] Proc. Inst. Civ. Engr., vol. 174, pp. 317 to 331.

determined. It contains also the calculated values of the theoretical velocity of discharge c_o, determined for the cross-section of the opening at the point of measurement under the assumption of adiabatic flow, and the actual velocity c_1 determined from the equation of continuity $c = \frac{G\,v}{F}$

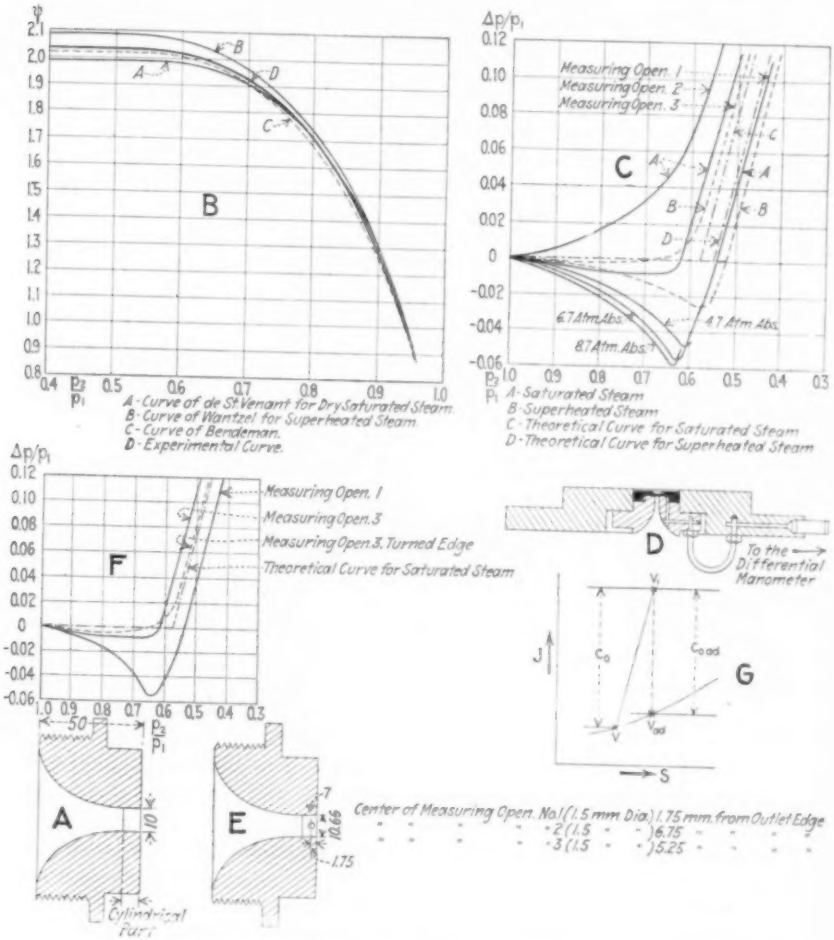

ψ
A
B
C
D
A - Curve of de St Venant for Dry Saturated Steam.
B - Curve of Wantzel for Superheated Steam.
C - Curve of Bendeman.
D - Experimental Curve.
Δp/p₁
Measuring Open. 1
Measuring Open. 2
Measuring Open. 3
6.7 Atm. Abs.
8.7 Atm. Abs.
4.7 Atm. Abs.
A - Saturated Steam
B - Superheated Steam
C - Theoretical Curve for Saturated Steam
D - Theoretical Curve for Superheated Steam
Measuring Open. 1
Measuring Open. 3
Measuring Open. 3, Turned Edge
Theoretical Curve for Saturated Steam
To the Differential Manometer
Cylindrical Part
Center of Measuring Open. No. 1 (1.5 mm Dia.) 1.75 mm. from Outlet Edge

FIG. 8 FLOW OF STEAM THROUGH ORIFICES AND PHENOMENA OF SUPERCONDENSATION

where v is the volume at the end of adiabatic expansion; a is the velocity of sound for the given section $= \sqrt{gkpv}$. This table shows the surprising facts that (*a*) the calculated values $\phi = \frac{c}{c_o}$ in the case of saturated steam and high velocities are greater than unity, but are below 1, and thus represent possible magnitudes, in the case of superheated steam. (*b*) The ve-

locities c obtained for both kinds of steam with large pressure falls exceed considerably the velocities of sound in the section of the opening at the respective state of the steam. The fact that some of the values for the coefficient ϕ are impossible can be explained by the fact that the values of v used were too large, and those of c_0 too small, which would indicate that the expansion curve of steam flowing through a simple orifice differs from an adiabatic curve even when there is no friction and no action of the orifice walls, but must be represented by some curve so constituted

TABLE 3 EXPERIMENTS WITH THE "SIMPLE ORIFICE"

Pressure p_1 atm. abs.	Pressure Ratio $\frac{p_2}{p_1}$	Coefficient ψ	c_1	c_0	ϕ	a
6.69	0.3705	2.037	489.2	480.5	1.018	447.9
6.69	0.4760	2.035	490.6	482.5	1.017	447.5
6.71	0.5172	2.037	489.6	482.0	1.016	447.5
6.72	0.5385	2.030	.....	.....	.....	.....
6.71	0.5685	2.034	483.4	477.7	1.012	447.8
6.70	0.6478	2.008	436.4	435.3	1.003	450.0
6.71	0.6945	1.944	389.0	394.2	0.987	452.8
6.70	0.7402	1.871	.....	.....	.....	.....
6.70	0.7952	1.728	.....	.....	.....	.....
6.70	0.8336	1.599	265.8	275.2	0.966	458.4
6.68	0.8898	1.353	.....	.....	.....	.....
6.69	0.9425	1.007	.....	.....	.....	.....
6.71	0.9475	0.963	141.0	149.9	0.941	463.0
6.64	0.4828	2.058	499.5	481.0	1.038	442.2
6.65	0.6986	1.945	.....	.....	.....	.....
6.64	0.8360	1.594	.....	.....	.....	.....
6.65	0.1990	2.040	494.8	480.5	1.030	442.0
6.73	0.3330	2.043	533.3	540.5	0.987	522.0
6.68	0.6402	2.015	454.2	460.8	0.986	532.0
6.70	0.6934	1.950	410.5	417.7	0.983	535.0
6.71	0.8316	1.609	290.3	299.5	0.969	546.5
6.77	0.2025	2.044	.....	.....	.....	.....

that the heat fall is completely transformed into kinetic energy; it is only with such a curve that the conditions of $v < v_{sa}$ and $c_0 > c_{0\,sa}$ (Fig. 8 G) are satisfied. The discrepancy in the case of a simple orifice between the theoretical and actual values, can therefore be ascribed to "supercondensation" (*Überkondensation*), the final state of the steam in the actual process of expansion showing a lower specific amount of steam x than would be the case with the adiabatic expansion. A phenomenon analogous to supercondensation is the *retardation of evaporation* observed in the case of flow of hot water, causing the amount of flowing water to be different from what is expected with an adiabatic flow. For smaller pressure falls either the influence of supercondensation decreases, or the friction losses become more important, either of which causes or both together reduce the value of ϕ below unity. In the case of superheated steam the values of the ordinates of the ϕ-curve are all less than unity.

The author disagrees with Christlein (*Zeits. des Vereines deutscher ingenieure*, December 16, 1911, and *The Journal*, February 1912, p. 310) who with a simple orifice obtained velocities as high as 800 $^{m}/_{sec.}$ (2625 ft. per sec.). He states that this is due to errors in measurement; the author in his experiments never had any velocities above 533 $^{m}/_{sec.}$ (1747 ft. per sec.). In the second part of the article it is shown that with Zoelly nozzles actual outlet velocities up to 800 $^{m}/_{sec.}$ (2625 ft. per sec.) can be obtained, but the tests have shown that this valuable property of the Zoelly nozzle is due solely to the bevelled edge, and, like in all other nozzles, the pressure fall inside the opening can be utilized only up to a certain degree. The author has also investigated the de Laval nozzles with a curved passage axis, and shows that the converging part of the de Laval nozzle behaves in the same manner as a simple orifice, and that the friction losses in the converging nozzle are small, while in the diverging large (this is really only a confirmation of what was generally supposed to be the case). On the basis of the deviations from the theoretical values which the author claims to have shown, he believes that the methods hitherto used for the design of steam turbines ought to be changed in some respects.

Maihak Indicator with the Böttcher Power Counter (*Der Maihak-Indikator mit dem Böttcherschem Leistungszähler*, A. Böttcher, *Elektrotechnik und Maschinenbau*, vol. 31, no. 3, p. 58, January 1911, 1913. 2 pp., 2 figs. *d*). Description of a special attachment (Fig. 9) invented by the author to be placed on an indicator and give direct readings of the output of an engine, without requiring the use of planimeter devices. The rather complicated theory of the apparatus has been explained by the author in *Zeits. des Vereines deutscher Ingenieure*, vol. 54, no. 30., p. 1233, July 23, 1910, and may be briefly stated as follows: The column *a* (Fig. 9) is provided at *c* with an angular lever of which the horizontal arm joins at *p* the piston rod of the indicator, while the vertical arm provides a connection with the counting arm proper which consists essentially of an axis located in the plane of the middle sections of the drum and column, and carrying the counter wheel *e*; on the axis of the latter sits a little worm which operates another counter wheel (Fig. 9 B). A weak spring *f* produces a certain definite adhesive pressure of the counter wheel *e* against the indicator drum. While the counter is in action, the counter wheel *e* is only once set into motion by the drum itself, while at the same time the axis of the counter wheel located in the casing *d* is displaced by the action of the angular lever *c* radially with respect to the indicator drum. Through these two simultaneous motions, the element of the arc of the counter wheel traveled through is made proportional to the angle of rotation of the indicator drum, which means proportional to the element of the path of the piston; but it is also proportional to the indicated pressure p_i in the cylinder measured by the indicator piston and its spring. From this it follows that the arc of the counter wheel passed through in a certain time is proportional to $\int p_i \cdot ds$, or to the indicated work in that time. It is characteristic for this device that it subtracts automatically the negative work during the piston stroke,

by the reverse motion of the counter wheel due to the corresponding movement of the indicator drum.

The author states that although several attempts have been formerly made to construct self-integrating indicators, they have all practically failed since an indicator of that kind can work only when the following formula is adhered to:

$$\epsilon J \leq f N r$$

where ϵ is the greatest occurring angular acceleration of the counter wheel; J the moment of inertia of the counter wheel with respect to

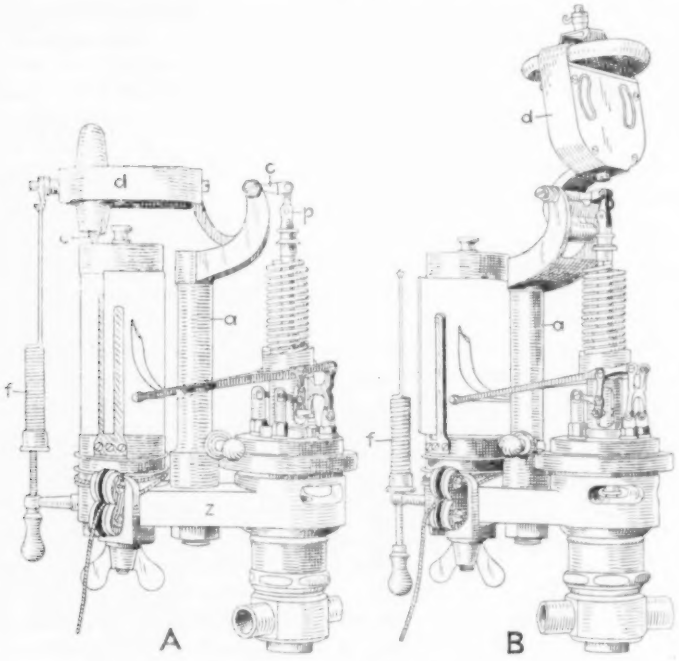


FIG. 9 BOETTCHER POWER COUNTER

its axis; f coefficient of friction of rest between the counter wheel and the surface of the indicator drum; N adhesion pressure of the counter wheel; r radius of the counter wheel. The indicator is said to have proved very satisfactory on the testing stand.

COMPENSATING PIPE JOINTS (*Kompensierende Rohrverbindungen*, H. Menk. *Die Turbine*, vol. 9, no. 7, p. 117, January 5, 1913. 5 pp., 8 figs. *d*). The length variation of a pipe when superheated steam at 12 atmospheres and 400 deg. cent. (752 deg. fahr.) is used is 2.2 times greater than when saturated steam at the same pressure is used. It is important, therefore, to use some device for allowing the free expansion and subsequent contraction of the pipe joint, the lyre-shaped compensating pipe having been

the first to be so used. While simple and cheap, it can be used only where the conditions of space permit it, and the diameter of the pipes is comparatively small. The metal hose has been found quite serviceable in this connection and has been successfully used up to 15 atmospheres pressure. The Gesellschaft für Hochdruckrohrleitungen, of Berlin, Germany, has introduced a *flat* lyre-shaped compensating pipe (Fig. 10 A), and claims that its compensating capacity has been thereby increased fourfold. A more ambitious form of compensating device is the joint connection, which may provide freedom of motion in a single or in several planes. The article describes the Koenig joint compensating pipe, of which all the types have the same system of packing by means of a thin specially prepared packing cord and pressing ring, thus avoiding the troublesome grind-

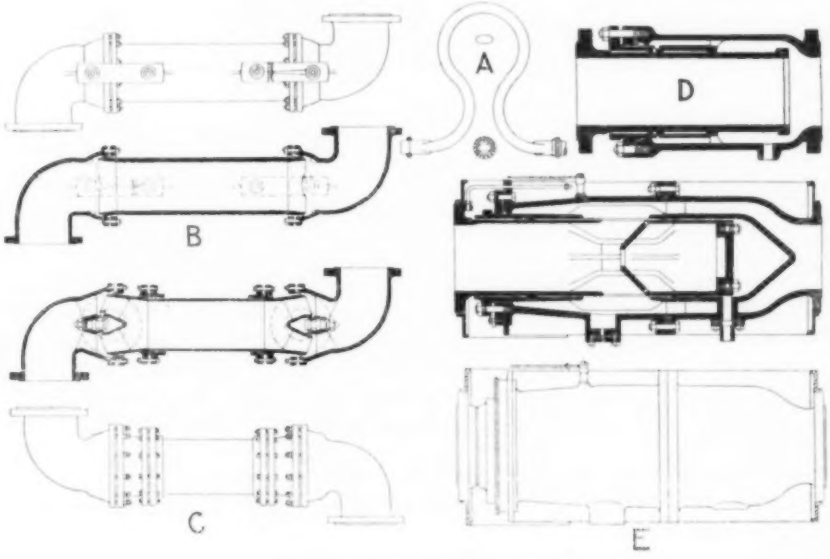


FIG. 10 COMPENSATING PIPE JOINTS

ing of packing surfaces. There are two main types: the knee joint (Fig. 10 B, freedom of motion in one plane) and ball joint (Fig. 10 C, freedom of motion in several planes). Pipe compensators may generally be balanced (Fig. 10 D) and not balanced (Fig. 10 E), the balancing being attained by placing that part into which the joint projects, in communication with the atmosphere, so that the motion of the expanding part of the joint has to overcome only the frictional resistance of the packing. This requires of course the use of extra stuffing boxes and more space, but since the extension is along the axis of the pipe there is plenty of room. The Koenig apparatus are nearly all made of steel castings. It is claimed that this device can take up the expansions due to heat as well as the vibrations produced by the action of the turbine.

CALCULATION OF THE DISTRIBUTION OF STRESSES IN ROTATING DISCS OF VARIABLE WIDTH (*Über die Berechnung der Spannungsverteilung in rotierenden Scheiben mit veränderlicher Breite*, Th. Pöschl. *Zeits. fur das gesamte Turbinenwesen*, vol. 10, no. 5 and 6, pp. 70 and 90, February 20 and 28, 1913, 6 pp., 6 figs. *mpA*). The problem of the distribution of stresses in rotating discs of variable width is treated by the application of the comparatively new *principle of variation*, according to which the actually occurring state of stress gives the minimum value to the work consumed in the change of form (potential energy) of the medium subjected to deformation. If this work consumed in the change of form be expressed by the displacements ξ, then, for uni-dimensional problems, to which belongs also the present one, an expression for this work is obtained in the following form:

$$A=\int_1^2 F\left(\frac{d\xi}{dx}, \xi, x\right) dx = \text{minimum} \quad \ldots\ldots [1]$$

where F is a known function of its argument.

The limiting properties of the integral require the disappearance of the Lagrangian derivation

$$\frac{d}{dx}\left(\frac{\partial F}{\partial\left(\frac{d\xi}{dx}\right)}\right)-\frac{\partial F}{\partial \xi}=0 \quad \ldots\ldots [2]$$

which is the differential equation of the unknown function $\xi=\xi(x)$.

For the approximate solution of this problem W. Ritz, the originator of this method, uses for the unknown function an expression of the form:

$$\xi^{(n)}=a_1P_1(x)+a_2P_2(x)+\ldots\ldots\ a_nP_n(x) \quad \ldots\ldots [3]$$

where the functions $P_i(x)$ are so selected that they satisfy both the limit and the symmetry conditions of the problem which in most cases have to be established fully beforehand; a_i denote the unknown as yet coefficients. Equation [3] is then used in connection with the integral in [1], and the integration performed, so that A appears to be expressed by the coefficients:

$$A=A(a_1, a_2 \ldots\ldots a_n) \quad \ldots\ldots [4]$$

and is, in most cases, a quadratic functions of these coefficients. If now A as a function of a_i reaches its limiting value, the necessary conditions for this may be expressed as:

$$\frac{\partial A}{\partial a_1}=0, \quad \frac{\partial A}{\partial a_2}=0, \ \ldots\ldots \ \frac{\partial A}{\partial a_n}=0 \quad \ldots\ldots [5]$$

The coefficients a_i act therefore as statically undeterminable magnitudes, of which there is an infinite number, in accordance with the equilibrium problem of continuity in one dimension. But with a suitable selection of the $P_i(x)$ functions this method proves to be very rapidly converging, so that in [3] only few members of the series have to be determined for practical purposes. The integration of the Lagrangian differential equation [2] is eliminated, and instead certain finite integrals have to be determined and purely algebraic operations performed.

Derivation of the Differential Equation of a Rotating Disc from the Principle of the Least Effort producing Change of Form. In Fig. 11 the following notation is used: $y=y(x)$ is the usual equation of the limiting curve of the half-disc referred to the system of axes x, y shown in the figure, with the disc symmetrical to the axis x; R radius of the disc in cm; v ratio of contraction of cross-section (for

iron = 1/3); μ density of the disc material (for iron = 7.7×10^{-3} kg/qcm^3); ω angular velocity per sec.; E modulus of elasticity (for iron = 2.10^6 kg/qcm); ξ radial displacement of the point at distance x from 0; ϵ_r, ϵ_t radial and tangential elongations; σ_r, σ_t radial and tangential stresses (referred to unit of area).

The most important assumption, apart from that of homogeneity of material, for the numerical calculation of rotating discs is that the phenomena are considered in a plane. Of course this applies primarily to thin discs, but it has been found that also in the case of thicker discs this method permits of obtaining average values sufficient for practical purposes.

The total effort consumed by the change of form consists of the potential energy of the elastic forces A_1 and the potential energy of the centrifugal forces A_2. As shown first by Prof. H. Lorenz, the equation that has to be made a minimum, is

$$A = A_1 - 2A_2 \quad \ldots\ldots [6]$$

It is further known that for the problem in the plane

$$A_1 = \int_{(w)} \left(\frac{\sigma_r^2 + \sigma_t^2}{2} - v\,\sigma_r \sigma_t \right) dw$$

The stresses are in the following functional relations with the elongations

$$\epsilon_r = \frac{d\xi}{dx}, \qquad \epsilon_t = \frac{2(x+\xi)\pi - 2x\pi}{2x\pi} = \frac{\xi}{x} \quad \ldots\ldots [7]$$

according to elasticity law:

$$\sigma_r = \frac{E}{1-v^2}\left(v\cdot\frac{\xi}{x} + \frac{d\xi}{dx} \right) \text{ and } \sigma_t = \frac{E}{1-v^2}\left(\frac{\xi}{x} + v\frac{d\xi}{dx} \right)$$

the volume element is taken as $dw = y\,.\,dx\,.\,x$, since the disc is symmetrical with respect to the center, and therefore $d\phi = 1$.

Therefore

$$A_1 = \frac{E}{2(1-v^2)} \int_0^R \left\{ \left(\frac{d\xi}{dx} \right)^2 + 2v\frac{\xi}{x}\frac{d\xi}{dx} + \frac{\xi^2}{x^2} \right\} x\,.\,y(x)\,.\,dx \quad \ldots\ldots [8]$$

and

$$A_2 = \frac{1}{2}\int_{(w)} \mu x\omega^2\,.\,\xi\,.\,dw = \frac{1}{2}\mu\omega^2 \int_0^R x^2\,.\,y\,.\,\xi\,.\,dx \quad \ldots\ldots [9]$$

and for

$$A = \frac{(1-v^2)}{E}\mu\omega^2$$

also

$$A = \int_0^R \left[\left(\frac{d\xi}{dx} \right)^2 + 2v\,.\,\frac{\xi}{x}\,.\,\frac{d\xi}{dx} + \frac{\xi^2}{x^2} - 2A\,.\,x\,.\,\xi \right] x\,.\,y\,.\,dx \quad \ldots\ldots [10]$$

the unknown function $\xi = \xi(x)$ being further determined by the condition

$$A = \text{minimum} \quad \ldots\ldots [11]$$

If the Lagrangian derivation [2] be constructed, after some reductions the differential equation of this problem will be obtained in its usual form

$$\frac{d^2\xi}{dx^2} + \left(\frac{d\log y}{dx} + \frac{1}{x} \right)\frac{d\xi}{dx} + \left(v\frac{1}{x}\frac{d\log y}{dx} - \frac{1}{x^2} \right)\xi + Ax = 0 \quad \ldots\ldots [12]$$

which can be fully integrated for $y = \text{const.}$, and $y = c\,.\,x^n$.

The general integral of this differential equation of the second degree contains two constants which are usually determined from the following limiting conditions:

$$\begin{aligned} &x=0,\ \xi=0,\ \sigma_r=\sigma_t \qquad \text{(disc fixed in the middle)} \\ &x=R,\ \sigma_r=0 \qquad\qquad \text{(edge of disc free of stress)} \end{aligned} \quad \ldots\ldots\ldots [13]$$

In the preceding the entire disc only is considered.

The author proceeds to simplify somewhat formula [10] by introducing a new independent variable through a new condition, and then gives numerical examples showing the application of this method to the calculation of discs of

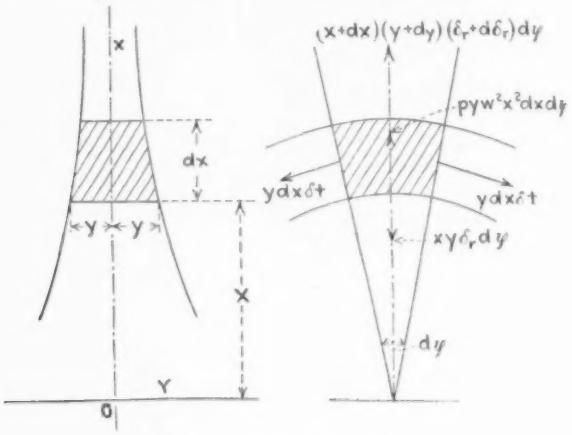


Fig. 11 Stresses in Rotating Discs

uniform width and of trapezoidal and parabolic section. Owing to lack of space, only the first is reported.

By introducing the condition

$$u=\frac{x}{R},\quad x=R.u,\quad dx=R.du \ldots\ldots\ldots\ldots\ldots\ldots [14]$$

the author obtained, after some simple substitutions, the equation

$$A=\int_0^1 \left\{\left(\frac{d\xi}{dx}\right)^2+2v\,\frac{\xi}{x}\cdot\frac{d\xi}{dx}+\frac{\xi^2}{x^2}-ax\xi\right\} xydx \ldots\ldots\ldots\ldots [15]$$

and has found further that the value

$$\xi^{(1)}=a_1\left(x-\frac{1+v}{3+v}x^3\right) \ldots\ldots\ldots\ldots\ldots\ldots [16]$$

would satisfy the conditions imposed.

He proceeds to substitute the value of [16] in [15], and after performing the integration and eliminating some unimportant factors, obtains

$$A^1=\frac{1+v}{3+v}\,a_1^2-\frac{a}{8}\,a_1 \ldots\ldots\ldots\ldots\ldots\ldots [17]$$

The value of the coefficient a_1 is determined from equation [5] and in this case

$$\frac{\partial A^1}{\partial a_1}=\frac{2(1+v)}{3+v}a_1-\frac{a}{8}=0 \ldots\ldots\ldots\ldots\ldots\ldots [18]$$

from which

$$a_1 = \frac{a}{16} \cdot \frac{3+v}{1+v} = \frac{AR^2}{8} \cdot \frac{3+v}{1+v}$$

The resultant change of form is then expressed by:

$$\xi^{(1)} = \frac{AR^2}{8} \cdot \frac{3+v}{1+v} \left\{ x - \frac{1+v}{3+v} x^3 \right\} = \frac{AR^2}{8} \left(\frac{3+v}{1+v} x - x^3 \right) \ldots\ldots\ldots\ldots [19]$$

In this case the expression obtained with the first term only determined gives an exact solution of the problem, the coefficients a_2, a_3.... all being equal to zero. This is not always the case, but the series used in this process are said to be always rapidly converging.

Thermodynamics

EQUATION OF STATE OF SOLID BODIES AND THEORIES OF SPECIFIC HEAT (*Die Zustandgleichung des festen Körpers und die Theorie der spezifischen Wärme*, Ew. Rasch. *Mitteilungen aus dem Kgl. Materialprüfungsamt zu Gross-Lichterfelde West*, vol. 30, nos. 5 and 6, p. 320, 1912. 28 pp., 15 figs. *et*). The author investigated the relation between the specific heats of solid bodies $\left(c = \frac{dQ}{dT} \right)$ and temperature T, and found that the Einstein-Nernst-Lindemann heat equations were unsatisfactory because the upper limit of the molecular heats of solid bodies is not a universal constant, as supposed, but a particular constant for each given material (*Materialkonstante*) (C). usually larger than might have been expected from the Einstein-Nernst theory. The author derives the main thermodynamic equation for solid bodies. A bibliography of the subject is appended.

Miscellanea

THE MYRIAWATT, A PROPOSAL FOR AN INTERNATIONAL HEAT UNIT (*Der Myriawatt, ein Vorschlag zu einer international Warmeeinheit. Zeits. für Elektrotechnik und Maschinenbau*, vol. 16, no. 8, p. 81, February 20, 1913. 2 pp. *g*). An editorial warmly welcoming the move initiated by the American Institute of Electrical Engineers, and stating that the report brought on behalf of these bodies to the International Electrotechnical Commission in Zurich exceeds in importance anything that has been presented to it. This is considered the first step towards eliminating the misunderstanding due to the use in the English speaking countries of the B.t.u. and in the rest of the world of the calorie unit, which the Germans have clothed in a W.E. dress. The article cites several examples showing how helpful the introduction of the new unit for the wider understanding of the world's technical literature would be, and gives a comparison between the value of the myriawatt and a calorie. One myriawatt is equal to 8605.8 calories or WE.

RUSSIAN PATENT LAWS (*Russisches Patentgesetz, Dinglers polytechnisches Journal*, vol. 328, no. 3, p. 47, January 18, 1913. 1 p. *g*). Abstract of the new Russian regulations as to the expropriation of patent rights. According to the patent law of July 1912, the government has the right to expropriate any patent,

whether already granted or only applied for, when necessary for the defense of the empire. An imperial order is required in each case and the patentee or his assignees or successors receive a compensation based on the actual benefit that the patentee might have derived from the exploitation of his invention; when such compensation may be inadequate, the advantage which the state will derive from the use of the patent, may also be considered. The law states also the process for determining the amount of compensation when the inventor is not satisfied with what he is offered by the government. The matter is then decided by several government boards, with a special committee of the council of state acting as the court of last appeal. No general court can be appealed to in this matter.

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SABATHÉ ENGINE (*The Journal*, December 1912, p. 2087). Cp. description of same in *Internal Combustion Engineering*, February 19, 1913, p. 108.

DIVING APPARATUS WESTFALIA (*The Journal*, November 1912, p. 1900). Cp. description of same in *Glückauf*, vol. 49, no. 8, p. 273, February 22, 1913.

REPORTS OF MEETINGS

BOSTON MEETING, FEBRUARY 25

At a meeting of the Society in Boston on February 25, the principal paper was presented by Prof. C. L. Norton, Mem. Am. Soc. M. E., on Transfer of Heat through Concrete. The results of a large number of experiments extending over several years, with respect to various properties of concrete as affected by heat, were described. The specimens tested were composed of a variety of aggregates and were tested at ages varying from a few weeks to five or six years. Some tests covered the lineal expansion, effect of heat on tensile and ductile strengths, etc., these specimens being mostly in the form of cubes and small beams. The most extensive series of tests had to do with the transfer of heat through a concrete body, several methods being used. Among those favored was one in which the concrete was disposed in the form of a cylinder, heat applied by a rod at the center, heated by electric current, similar to the method used in testing pipe coverings; also experiments were made on flat concrete plates.

G. E. Fisher, engineer of the Arkwright Mutual Fire Insurance Companies, followed with a brief paper in which he called attention to the time element as a factor in the efficiency of fire-resisting material, and pointed out that much of the spalling of concrete during fires was really due to the water from hose streams. He also called attention to the varying degrees of protection offered by the proper and improper application of concrete.

Both of these papers were illustrated by lantern slides. A general discussion followed their presentation.

NEW YORK MEETING, MARCH 13

At the joint meeting of the New York Section of the Illuminating Engineering Society with The American Society of Mechanical Engineers, the New York Association for the Blind and the American Museum of Safety, on Thursday evening, March 13, Dr. Ellice M. Alger presented a paper on Illumination and Eyestrain. Eyestrain results from compelling eyes to do work which is beyond their physiological capacity. The results of eyestrain are manifold and include, among other things, pains in the eyes, functional defects of vision, general nervous exhaustion and irritability; they also cause 80 per cent of the chronic headaches. The speaker fully discussed the harmful influence on the eyes of the actinic part of the light spectrum and over-bright light, and pointed out that the number of accidents in industrial plants approach a minimum in July and August, and increase to a maximum in the dark winter months, the influence of day-

light in preventing accidents being more evident in occupations which require not so much bright light as diffused light without shadows over large areas. Good lighting, which is entirely different from intensely bright lighting, even when estimated by its actual cost in dollars and cents, is often less expensive than bad, while from the standpoint of efficiency there can be no comparison.

Ward Harrison discussed the industrial lighting problem from the standpoint of the illuminating engineer, and showed that good lighting pays, and that plenty of light but no glare should be the thing striven for.

A. C. Jackson said that the mechanical engineer has to take up these problems where the architect, illuminating engineer, and others leave off. The importance of good lighting is more and more appreciated, and as a result concrete and metal sash constructions are making daylight available during 92 per cent of the regular working year, whereas, due to poor design of buildings and poor location of machines and benches, it was formerly available during only about 80 per cent of the regular working year. More money can be saved by proper design of buildings and proper location of machinery and benches in relation to light than by the use of Mazda or mercury lamps. The latest type of building for accomplishing this purpose is the saw-tooth. This talk was illustrated by a number of slides.

Dr. W. H. Tolman of the American Museum of Safety showed a number of slides illustrating the role of lighting with respect to the problem of safety, taken from the practice both of this country and Germany.

CINCINNATI MEETING, MARCH 20

At a meeting of the Cincinnati Section of the Society on March 20 in the Engineers' Club of that city, Dr. William Kent, Mem. Am. Soc. M. E., gave an address on Engineering and Common Sense. A. L. DeLeeuw, chairman of the section, presided, and Dr. Kent's remarks were discussed by James B. Stanwood, Parker H. Kemble and C. M. Stegner. About 100 were in attendance. Previous to the meeting a dinner was given in honor of Dr. Kent in the club dining room, at which members of the Society and of the club were present.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

On March 5, 1913, the Armour Institute of Technology Student Branch held its sixth regular meeting. The speaker of the evening was T. A. Peebles, Mem. Am. Soc. M. E., on the subject of Furnace Design. Various types of furnaces were illustrated by means of numerous lantern slides. At the conclusion of the lecture, Prof. G. F. Gebhardt, B. H. Jarvis and J. J. Hayes participated in the discussion.

COLUMBIA UNIVERSITY

At a meeting of the Columbia University Student Branch on March 6, Prof. C. P. Berkey gave an illustrated lecture on the Catskill Aqueduct, in which he emphasized particularly the difficulties due to the peculiar formations of the region along the Hudson River, which the geologists had to overcome to make this enormous project a success.

CORNELL UNIVERSITY

On February 18, George A. Orrok, Mem. Am. Soc. M. E., spoke to the Sibley College Student Branch on the subject of The Development of the Power Plant. The entire senior class attended the meeting.

LEHIGH UNIVERSITY

The Mechanical Engineering Society of Lehigh University was entertained on the evening of February 25 at the home of Dr. Drinker, President of the university. J. H. Sheppard (1913) read a paper on the Modern Tendencies in Marine Propulsion, in which he discussed the various systems of marine propulsion in present use and their future. Dyer Smith of New York then gave an address on Patent Experting.

PENNSYLVANIA STATE COLLEGE

K. C. Grant of Pittsburgh, Pa., addressed the meeting of the student section of Pennsylvania State College on February 7, upon The Conservation of Water Supply and Power, with special reference to its European aspects.

On February 21, a lecture on Cork and its Uses was given by Mr. Prentice of the Armstrong Cork Company of Pittsburgh. This was illustrated by lantern slides and showed the production, manufacture and application of cork.

PURDUE UNIVERSITY

Prof. C. B. Veal, Mem. Am. Soc. M. E., addressed the student section of Purdue University on February 25, his subject being The Progress of Aviation from an engineering standpoint.

STEVENS INSTITUTE OF TECHNOLOGY

At a meeting of the Stevens Engineering Society on February 11, Rudolph Hering, Mem. Am. Soc. M. E., addressed the members on Sewage Disposal. J. H. VanderVeer discussed the subject at the conclusion of the address.

Dayton C. Miller gave an interesting lecture before the society on February 18, on Sound Waves and How to Analyze them.

On February 28, E. H. Peabody of the Babcock and Wilcox Company, New York, spoke upon Marine Boilers at a meeting of the organization.

On March 4, the Hell Gate Bridge and the New York Connecting Railway, was presented by Henry Hornbostel; and on March 10, a paper on Leather was read by Allen Rogers.

The following officers were elected on March 11: L. F. Bayer, president; R. Trowbridge, vice-president; C. H. Colvin, secretary; S. S. Parsons, treasurer; L. E. Saxby, assistant secretary.

UNIVERSITY OF CINCINNATI

On February 19, A. J. Baker of the Cincinnati Milling Machine Company addressed the University of Cincinnati Student Section on The Engineer's Relation to the Sales Department in a Modern University. He described the methods and the manner of analysis used by the sales engineer in making estimates on time required to do work with machines, jigs and special tools, and exhibited lantern slides showing some of the results obtained.

UNIVERSITY OF ILLINOIS

On February 15 the annual smoker of the Student Branch at the University of Illinois was held at Hessel Hall, and was perhaps the most successful smoker ever held by the society. About two hundred were in attendance. An unusual number of good speeches were made by different members of the faculty. Prof. C. R. Richards closed the meeting by a talk on the future of the mechanical engineering course, outlining carefully the plans of the department concerning its growth and ideals. He congratulated those present on their wise choice of a profession, and urged each one to interest those who had a tendency toward engineering to take such a course.

Prof. E. C. Schmidt, Mem. Am. Soc. M. E., lectured on The Locomotive as a Power Plant on February 21. The general theme of this talk brought out the marvelous efficiency of the locomotive in view of the fact of the intensity of operation, and figures were also shown relative to the efficiency of the locomotive and that of the power plant. A general discussion followed.

UNIVERSITY OF MISSOURI

A very interesting discussion of Modern Machine Shop Methods was given at the March 3 meeting of the University of Missouri Student Branch, by Irwin Dunbar (Student 1911) and F. I. Kemp (Student 1911).

UNIVERSITY OF NEBRASKA

Railroad Shop Organization was the subject of a paper presented by W. O. Forman, head mechanical engineer of the Havelock Shops, C. B. & Q. R. R., at a meeting of the University of Nebraska Student Branch on March 4.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the current office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The list of "men available" is made up from members of the Socley. Further information will be sent upon application.

POSITIONS AVAILABLE

325 Young engineering graduate, mechanical or electrical engineer, for sales work in New York office.

330 Sales manager for concern manufacturing steam turbines and centrifugal pumps. Location New York. Apply through the Society.

332 Competent engineer, experience in sanitary and hydraulic lines, with initiative, good presence and ability to reason from cause to effect. Location New York. Salary $2000 to $2400 a year.

333 Instructor in theoretical work in electrical engineering; candidate must be a graduate of a leading engineering school and have experience in teaching, with considerable practical experience in electrical engineering. Salary about $1400 to start. Address Dean Calvin H. Crouch, University of North Dakota, Grand Forks, N. D.

334 Two young engineers with technical training as mechanical and electrical engineers, preferably one or two years' experience, for concern in Mexico in large plant for cyaniding ores. Positions would lead to assistant superintendency. Salary $200 Mexican currency per month and transportation down.

337 Mechanical draftsman experienced in design of large steam or gas engines. Only first class men need apply. Location Ohio. Apply through the Society.

339 Young engineer to take charge of purchasing and cost departments of established concern manufacturing ball bearings. Location Connecticut.

342 Operating engineer as assistant in engine room, boiler and pipe-fitting shop. Good opportunity. Location Connecticut.

343 Efficiency man, assistant in department of textile manufacturing concern. Location Connecticut.

345 Engineer, technical graduate, capable of going into field acquiring data and preparing designs for furnaces, machinery, mill construction and power-plant work, piping, etc. Salary to start $100. Location New Jersey.

347 Young engineer, with three to five years' experience in operation

of boiler plants wanted for Boston firm of consulting engineers. Man preferred who has been connected with the operation of boiler plants and utilization of steam in mills. Technical education desirable but not essential. Apply through the Society.

348 Steam engineer for power-house equipment. For one competent to take entire charge of power-plant operation and repairs, salary $150. Location Maryland.

349 Connecticut concern, desires three architectural draftsmen familiar with factory construction and manufacturing. Salary $20 to $40 a week.

350 Ohio concern; desires two draftsmen, a detailer and designer, on machine tools.

353 An old established house, branching into new line of work, desires services of recent technical graduate in mechanical or electrical engineering, preferably of one or two years' experience, to enter into contract for a term of years for service in the tropics. Must be of exceptional habits, in best health, able and active. Apply through the Society.

354 Head of mechanical department of large cloth finishing plant, to have charge of machine shops, carpenter and yard work, trucking, up-keep of machines and building, new work and repairs, electrical distribution. Position is practically master mechanic's, but would need good executive ability.

356 Instructor in mechanical engineering wanted by an eastern university; one with practical and teaching experience preferred; salary $1000 to $1200. Apply through the Society, giving details of training and experience and references.

MEN AVAILABLE

58 Member, experienced in the design and manufacture of pumping machinery would like to correspond with parties now building steam pumps who are about to take up centrifugal lines.

59 Mechanical engineer, desires position as works manager or assistant to superintendent; age 29, college training; five years' practical experience, holding positions as foreman of power plant repairs, erecting foreman, sales engineer and contractor. At present with large locomotive works.

60 Executive engineer desires position as superintendent or works manager, technical graduate with practical shop training and experience in organizing and handling men. At present assistant to general superintendent of works employing 6500 men.

61 Member, 34 years of age, desires position as works engineer; 15 years' experience in power plant design, construction and supervision piping, heating, mill engineering. At present head of engineering department of large plant, but desires change of location.

62 Technical graduate, age 37, practical mechanic with ten years' experience in executive capacity, mill engineering, power generation, transmission, etc., desires position as factory engineer or works manager with progressive concern in New England.

63 Assistant to purchasing agent; experienced in materials, miscel-

laneous machinery and matters pertaining to construction, contracts, specifications, general mechanical and electrical engineering.

64 Plant engineer, maintenance, inspection and construction departments, government, railroad and factory experience or as general engineering assistant.

65 Member, age 34, technical education, executive ability, experienced in design and installation of machinery, coal-handling plants, and with broad experience in the design and fabrication of all classes of structural steel and plate work, would be pleased to communicate with firm desiring to secure the services of a reliable hustler to take charge of work.

66 Mechanical engineer, graduate Stevens Institute of Technology, experienced in plant superintendence and construction, gas and steam engineering, boiler design, manufacture and sales, acquainted with territory in vicinity of New York City.

67 Young technical graduate employed as materials testing engineer, desires change of position and location, central or western states preferred.

68 Member, mechanical engineer and expert machinist, with ten years' experience in industrial and vocational education, desires executive position along that line. Can furnish best of references.

69 Sales manager, exceptional experience in design and selling boilers, engines and complete power plants, construction and installation. Specially good at getting results from branch offices and salesmen. Valuable acquaintance gained by 15 years' successful selling in territory east of and including Pittsburgh and Buffalo; both practical and technical training.

70 Contracting sales engineer for structural steel company. Junior member. Six years' general experience in steel business as draftsman, estimator and engineer. At present employed; for the past two years as contracting engineer for plate and structural shop, desires advantageous change. Confidential, apply through Society.

71 Technical graduate, 26 years of age, experienced in shop, teaching applied mathematics, experimental mechanics and engineering physics, 15 years in engineering and contracting, covering refrigeration, water supply, power and lighting plants including machinery and buildings, testing process development and consulting work over a wide range of subjects. At present acting professor of engineering practice in a prominent engineering school. Has no family and would like to find something to do in the Orient or south of the equator.

72 Mechanical engineer with splendid practical shop and commercial experience, expert in the up-to-date manufacture of interchangeable machinery and parts, resourceful in design and methods for reducing costs and increasing production, good organizer and system man with excellent executive ability. At present engaged, but for good reasons desires change. Splendid record and references.

73 Member, technical graduate, 12 years' experience designing and estimating, four years' field and shop experience, with working knowledge of electricity, is open for position. Outside construction or contracting work preferred. Excellent references.

74 Assistant professor desires change. Now in charge of a department in an eastern technical school. Best of reasons for change. Will consider openings for assistant professor or better grade in mechanical engineering; experienced in steam, hydraulic, gas engine, strength of materials, and cement laboratories and mechanical engineering subjects. Practical experience in consulting and testing engineering work. Best of references. Apply through the Society.

75 High-grade efficiency engineer desires change.

76 Junior, age 30, technical graduate experienced in the design, construction, operation and maintenance of power plants and sub-stations, testing electrical machinery, desires position of responsibility with hydroelectric company or with contractors doing power plant or hydroelectric work. Best references. $150-200 per month. At present employed.

77 Manager or engineer capable of taking charge of sales department, advertising and correspondence or shop.

78 Junior, graduate mechanical engineer, ten years' experience as superintendent construction; master mechanic in large factory; past three years with beet sugar company in charge of designing, constructing and operating numerous pumping plants, irrigation systems, pipe and power lines, accustomed to figuring cost and purchasing materials. Executive ability and excellent references; desires to make change about May 1.

79 Young engineer, technical training; five years' machine tool shop experience in various departments, desires to locate with engineering firm.

80 Junior member, experienced mechanical rubber goods superintendent and factory manager desires position in factory in the East.

81 Member, age 34, technical and practical training, desires position in vicinity of New York preferably, with mechanical or marine engineering concern; experienced in the design, construction and operation of stationary, marine, and submarine machinery, and special automatic and hydraulic machinery. Good draftsman and designer, licensed stationary and marine engineer. Past five years executive engineer in charge of industrial plants. At present employed. Excellent references. Salary according to position.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

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